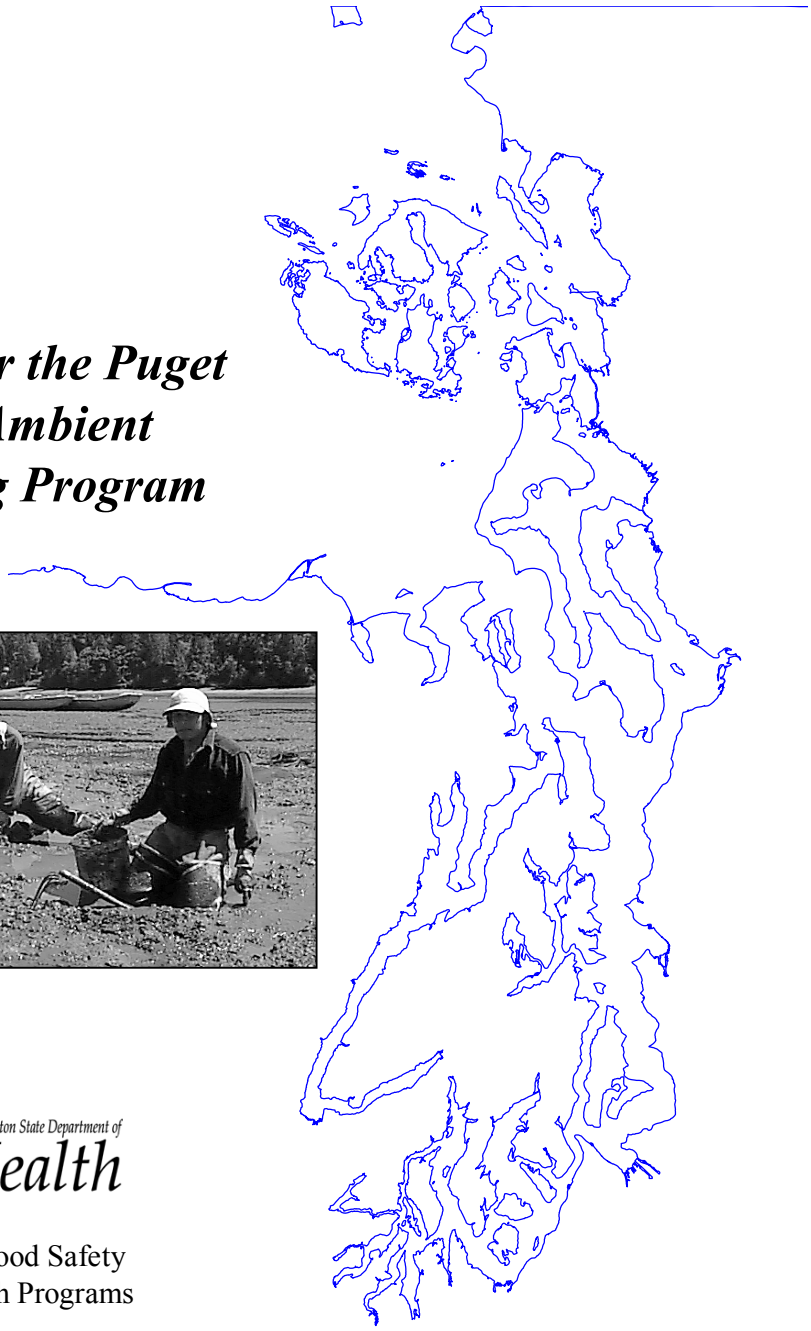
Status and Trends in Fecal Coliform Pollution in Puget Sound Year 2000

A Report for the Puget Sound Ambient Monitoring Program



Washington State Department of Health

Office of Food Safety
and Shellfish Programs

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A Report for the
Puget Sound Ambient Monitoring Program

Tim Determan
Washington State Department of Health
Office of Food Safety and Shellfish Programs

August, 2001

The Department of Health works to protect the health of the people of Washington State

Table of Contents

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I offer special appreciation to Wayne Clifford (DOH Office of Food Safety and Shellfish Programs), whose assistance in the design of software tools for calculations of statistics and graphical analysis has permitted a nearly four-fold increase in the number of shellfish areas reported to the Puget Sound Ambient Monitoring Program: from eleven in 1999 to over forty in 2001.

EXECUTIVE SUMMARY

One task of the Washington State Department of Health (DOH) is to protect shellfish consumers from eating contaminated shellfish. A component of this task is to monitor fecal pollution in water samples taken from over 100 commercial shellfish growing areas in Puget Sound. DOH also participates with other public agencies in the Puget Sound Ambient Monitoring Program (PSAMP). PSAMP is a comprehensive program to assess the health of Puget Sound. For PSAMP, DOH has analyzed the status and trends of fecal pollution in 43 commercial shellfish growing areas in Puget Sound through March 2000. The analysis focused on "core" areas (analyzed annually) and "rotational" areas (analyzed every three years) in the Main Basin of Puget Sound and Hood Canal. Twenty-six growing areas with a minimum threshold of pollution (at least one stations classed as **FAIR** or worse) were ranked according to impact. Individual stations in these areas with periods of record exceeding three years (221 of 707 or 31% of all stations) were examined for significant temporal trends.

Present Status:

- Status was determined for 713 stations in 43 commercial shellfish growing areas in Puget Sound (Appendix C, page 80): 84% of stations scored **GOOD**; 8% were **FAIR**; and 7% were **BAD**. (Categories are defined in the legend of Figure RESULTS-1 on Page 10.)

- Twenty-six of the 43 growing areas (60%) had at least one station that was affected by fecal pollution (i.e., status of **FAIR** or **BAD**). Eleven of the 23 "Rotational" areas in the Main Basin and Hood Canal were affected. The remaining 15 affected growing areas (mainly "Core" areas) were scattered throughout Puget Sound. Growing areas were ranked according to fecal pollution impact (see Figure RESULTS-2 on Page 11). The greatest impact this year was at South Skagit Bay, followed closely by Drayton Harbor.

Temporal Trends: A total of 103 of 225 stations (46%) in 26 growing areas showed increased pollution (Appendix B, page 79); 27% decreased; and 27% stayed the same.

Major Fecal Sources: Fecal coliform sources affecting all growing areas include failing on-site sewage systems and/or poor pasture management. Sources affecting Drayton Harbor, Henderson Inlet and Oakland Bay include contaminated urban stormwater and other assorted nonpoint sources. Drayton Harbor may also receive fecal wastes from boats. Portage Bay is affected primarily from dairy operations on the Nooksack River.

Individual Reports. An individual report was prepared for each of 26 growing areas affected by fecal pollution (i.e., one or more sampling station had a status that was less than **GOOD)**. These areas are as follows:

Strait of Georgia:

- Drayton Harbor (page 13)
- Portage Bay (page 15)
- Samish Bay (page 17)

North Puget Sound:

- South Skagit Bay (page 19)
- Saratoga Passage (page 21)

Strait of Juan de Fuca:

- Dungeness Bay (page 23)
- East Strait including Pysht (page 25)

Hood Canal:

- Port Gamble (page 27)
- Area 3 including Quilcene and Dabob bays (page 29)
- Area 3a including Dosewallips Delta (page 31)
- Area 5 including Lilliwaup (page 33)
- Area 6 including Annas Bay (page 35)
- Area 8 (page 37)
- Area 9 including Lynch Cove (page 39)

Main Basin Puget Sound:

- Lemolo in Liberty Bay (page 41)
- Chico Bay in Dyes Inlet (page 43)
- Port Orchard and Rich passages (page 45)
- Quartermaster Harbor on Vashon Island (page 47)

South Puget Sound:

- Nisqually Reach (page 49)
- Filucy Bay (page 51)
- Henderson Bay including Minter Bay (page 53)
- Burley Lagoon (page 55)
- Henderson Inlet (page 57)
- Eld Inlet (page 59)
- Oakland Bay (page 61)
- North Bay (page 63)

INTRODUCTION

DOH Mandate: There are over 100 intertidal and subtidal commercial shellfish growing areas throughout Western Washington. The Washington State Department of Health (DOH) classifies commercial shellfish growing areas and regularly monitors their condition to protect shellfish consumers from eating shellfish contaminated by fecal pathogens, biotoxins, and contaminants.

Puget Sound Ambient Monitoring Program: DOH is a partner in the Puget Sound Ambient Monitoring Program (PSAMP) because of its extensive monitoring activity. PSAMP is a multi-agency monitoring program coordinated by the Puget Sound Water Quality Action Team. PSAMP is a long-term comprehensive program to assess the health of Puget Sound.

PSAMP Analysis: This year, DOH analyzed for PSAMP the status and trends of fecal pollution through March 2000 in 43 Puget Sound shellfish growing areas of Puget Sound.

BACKGROUND

Development and Fecal Pollution Sources: Prior to the 1970s, the major threat to shellfish beds was wastewater discharged through pipes (i.e., point sources). This threat diminished after legally mandated wastewater treatment facilities were built. Since the early 1980s, nonpoint sources have become an increasingly important factor in closure of shellfish beds. Nonpoint sources include failed individual on-site sewage systems, unmanaged runoff from farms, sewage from boats, wildlife, etc. Rapid migration of people into Puget Sound during the last three decades and the growing "sub urbanization" of rural watersheds have increased the risk of pollution impacts on shellfish habitat.

Remedial Action: During the past decade, governments and citizens have dedicated considerable time and resources to control pollution in most Puget Sound watersheds. Remedial action has included (to greater or lesser degrees): agricultural best management practices; repair of failed individual on-site sewage systems; upgrading of municipal sewage facilities; construction of stormwater treatment facilities; installation of boat-waste disposal stations at marinas and marine parks; and watershed planning.

Classification of Shellfish Growing Waters: The Department of Health applies two components to classify a shellfish growing area:

1. **Shoreline Survey:** all significant point and nonpoint pollution sources along shorelines and in upland drainages are located and evaluated.
2. **Water Quality Sampling:** Sampling is done monthly at carefully selected stations in **Conditionally Approved** areas and six times a year in **Approved** and **Restricted** areas. **Prohibited** areas are generally not routinely monitored except when there are broader issues to address, such as an ongoing remedial action program (e.g. Drayton

Harbor). The stations are routinely sampled until minimums of 30 results per station are available. Two statistics (geometric mean and ninetieth percentile) are calculated from the 30 water sample results. These are compared to water quality criteria set by the National Shellfish Sanitation Program (NSSP).

The NSSP **Water Quality Criteria** are applied according to the type of pollution sources present:

1. The **geometric mean** is not to exceed 14 most probable number (MPN) of fecal coliforms per 100 milliliters of water sample (applied when point and/or nonpoint sources are present); and
2. The **ninetieth percentile** is not to exceed 43 MPN per 100 milliliters of water sample (applied to areas where only nonpoint sources are present); OR **ten percent** of results are not to exceed 43 fecal coliforms per 100 milliliters (applied in **Conditionally Approved** areas and those receiving point-source discharges).

(Note: The term "most probable number" refers to the multiple-tube fermentation method used by DOH for fecal coliform analysis. See METHODS on page 5.)

Both water quality criteria **must be met** in order to meet NSSP requirements. An area cannot be approved for harvest if the shoreline survey reveals significant pollution threats, even if water quality is acceptable. If water quality criteria are met **and** significant pollutant sources are absent, the area is classified as **Approved**. If pollution events are episodic and predictable (rain-related runoff, etc.), the area can be **Conditionally Approved**. An area subjected to unpredictable, but limited pollution is classified **Restricted**. Areas affected by chronically excessive and/or unpredictable pollution episodes are classified **Prohibited**. After classification, monitoring continues and shoreline surveys are periodically conducted to detect change.

Why Monitor Fecal Coliform Bacteria? Scientists measure fecal coliform bacteria in the environment to protect humans from contracting illnesses from pathogenic (illness-causing) microorganisms. Fecal coliforms are not generally pathogenic. Rather, they are a normal component of the assemblage of bacteria that inhabit the intestines of warm-blooded animals, including humans. Thus, they are "indicators" of the fact that fecal wastes have washed into the water. Shellfish are particularly effective at picking up water-borne fecal pollution because they filter their food out of the water, and can pick up and concentrate pollutants far above the levels in the water. Thus, the presence of significant numbers of fecal coliforms in the water is an indirect measure of risk that pathogens are there also.

"Early Warning" Program: Each year, DOH reviews data from growing areas throughout Washington State. DOH issues an "Early Warning" report to local and state government and private interests if a growing area is **Threatened**, according to the guideline below:

- A growing area is **Threatened** if the ninetieth percentile at one or more stations equals or exceeds 30 MPN per 100 milliliters of water (applied to areas where only nonpoint sources are present); OR **six percent** of results exceed 43 fecal coliforms per 100 milliliters (applied in **Conditionally Approved** areas and those receiving point-source discharges).

The ninetieth percentile (rather than the geometric mean) is used as the statistic to identify Threatened areas because experience has shown that ninetieth percentiles respond more quickly to change than do geometric means. Threatened growing areas are reported annually to shellfish growers, tribes, and local and state agencies.

Although the evaluation procedure for PSAMP and Early Warning are similar, they were designed independently to achieve different goals. The PSAMP analysis detects long-term change. The Early Warning analysis detects recent degradation of water quality, so that pollution sources, if present, might be located and repaired to prevent downgrades.

METHODS

Field and Laboratory Protocols: DOH uses a systematic random sampling (SRS) strategy (U.S. FDA 1995, 1997) when sampling fixed stations in shellfish growing areas. Under this strategy, each growing area is sampled at reasonably fixed intervals. Thus bias is controlled by sampling without focusing on any particular factor.

Surface samples for fecal coliform analysis are collected at each station according to APHA (1984). The samples are packed on ice and sent to the DOH Public Health Laboratory in Seattle. Analyses are run within 30 hours of collection. Fecal coliforms are analyzed with the multiple tube fermentation (MPN) procedure using A-1 broth (described in Method 9221 E *in* APHA 1995). Surface measurements of salinity and temperature are recorded, together with tide and weather conditions.

Selection of Growing Areas for PSAMP Analysis:

- **Core** areas are evaluated annually. Core areas have been harvested for many years, and harvest could potentially continue for many more. Core areas have been affected by nonpoint pollution, but control programs are in place and show potential for success. Parts of most Core areas are classified Conditionally Approved and are sampled 12 times a year.
- **Rotational** areas are examined every three years. Rotational areas include all **Approved** and **Restricted** areas. Approved areas are typically remote from pollution sources. Restricted areas are unpredictably affected by a limited degree of pollution and control programs usually haven't produced detectable

improvement. Thus, monthly sampling is fiscally unjustified. Approved and Restricted areas are sampled six times a year.

Rotational areas are divided among three regions. The north region includes north Puget Sound, the straits of Juan de Fuca and Georgia, and the San Juan Islands. The central region includes Main Basin Puget Sound (to the Tacoma Narrows Bridge) and Hood Canal. The third region is South Puget Sound (south and west of the Tacoma Narrows Bridge). This year's PSAMP analysis included all Core growing areas and Rotational areas in the central region (see Figure RESULTS-1 on page 10).

Calculations: Individual stations in each growing area were examined to see which stations had been most consistently sampled for the longest time. Next, for each selected station, the earliest date was found such that there were 30 results from that date backward. These were pooled, and a geometric mean and a ninetieth percentile were calculated. These statistics were then calculated for each following sampling date through March 2000. In other words, the statistics are "moving statistics" progressing forward through time to the most recent sampling date available. [Note: if multiple samples were taken within a single month, a single geometric mean value was calculated from all fecal coliform results obtained during that month.] The ninetieth percentile was selected as the statistic to measure status and trends because it responds more readily to change than the geometric mean. Statistics were calculated with Excel 5.0 (Microsoft Corp.). The statistics were then exported to STATISTICA 5.1 (Statsoft, Inc., Tulsa, OK) for statistical and graphical analysis.

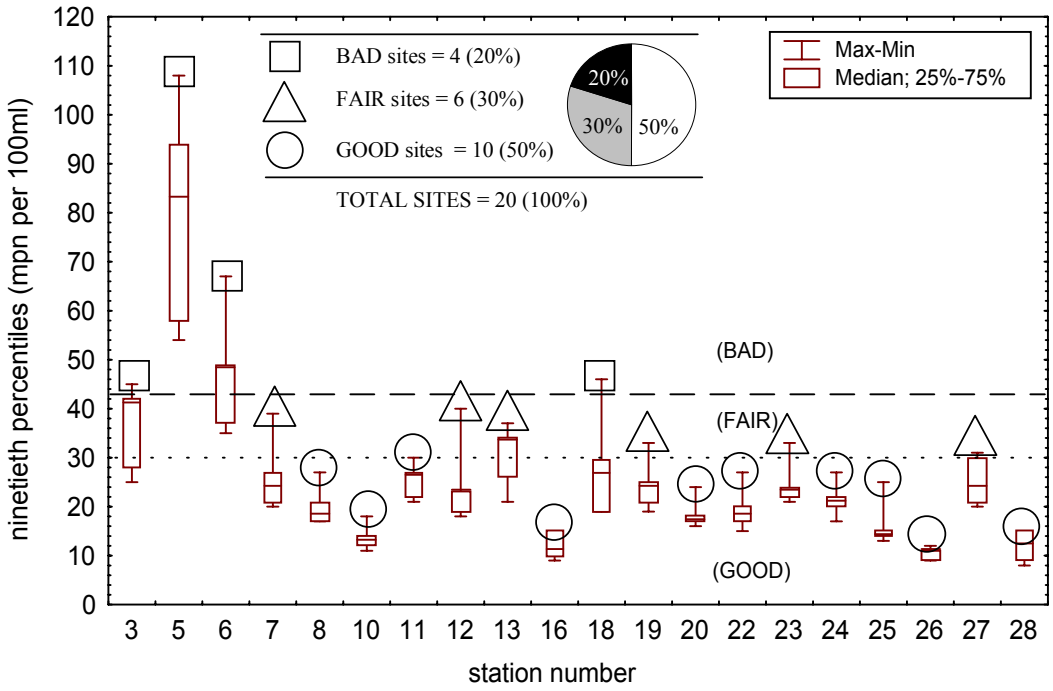
PSAMP versus Growing Area Classification: Some graphs in this report may show periods when the NSSP criteria were exceeded despite the station's location in an area that is Conditionally Approved (e.g., see Station 5 Henderson Inlet; Figure HNL-2b on page 58). An explanation of this seeming contradiction is that the NSSP statistics serve two separate DOH activities: (1) classification of growing areas and (2) PSAMP reporting. An initial calculation is done with results from 30 samples collected under a variety of pollution conditions ranging from minimum to heavy. Both activities use this first set of statistics. PSAMP uses them without further refinement to assess status and trends. For classifying growing areas, if the initial statistics comply with the NSSP criteria (and a sanitary survey uncovers no pollution impacts), DOH classifies the area Approved. However, if the initial statistics do not meet the Approved area criteria, DOH evaluates the data further to discover whether environmental factors that control water quality are known and predictable. If they are, DOH writes a harvest management plan that defines conditions under which harvest will be safe and classifies the area as Conditionally Approved. The most common Conditionally Approved classification is based on rainfall (see Appendix A). For example, Conditionally Approved Henderson Inlet is open except for a five-day period following a 24-hour rainfall total of 0.50 inch or more. Thus, graphs for the Conditionally Approved part of Henderson Inlet may show that the ninetieth percentiles are above the NSSP criterion, yet the area is open to harvest under managed conditions.

Growing Area Status: The status of each growing area was determined using "box plots" that show ranges of ninetieth percentiles for each station during the period from January 1999 through March 2000 (see Figure METH-1). Each station was sorted into categories of **GOOD**, **FAIR**, or **BAD** in the following manner:

- A station scored **GOOD** if the highest ninetieth percentile did not exceed the Threatened threshold (See **"Early Warning" Program** on page 5) of 30 MPN per 100ml (values enclosed by circles;).
- A station scored **FAIR** if its highest ninetieth percentile was higher than 30 MPN per 100ml, but did not exceed the NSSP criterion of 43 MPN per 100ml (values enclosed by triangles).
- A station scored **BAD** if its highest ninetieth percentile was above the NSSP criterion (values enclosed by squares).

Figure METH-1 shows that 10 of 20 stations (50%) in Henderson Inlet were GOOD, 6 (30%) were FAIR, and 4 stations (20%) were BAD. The pie chart of the percentages provides a single image of the status of Henderson Inlet with which to compare other growing areas similarly analyzed (Figure RESULTS-1, page 10).

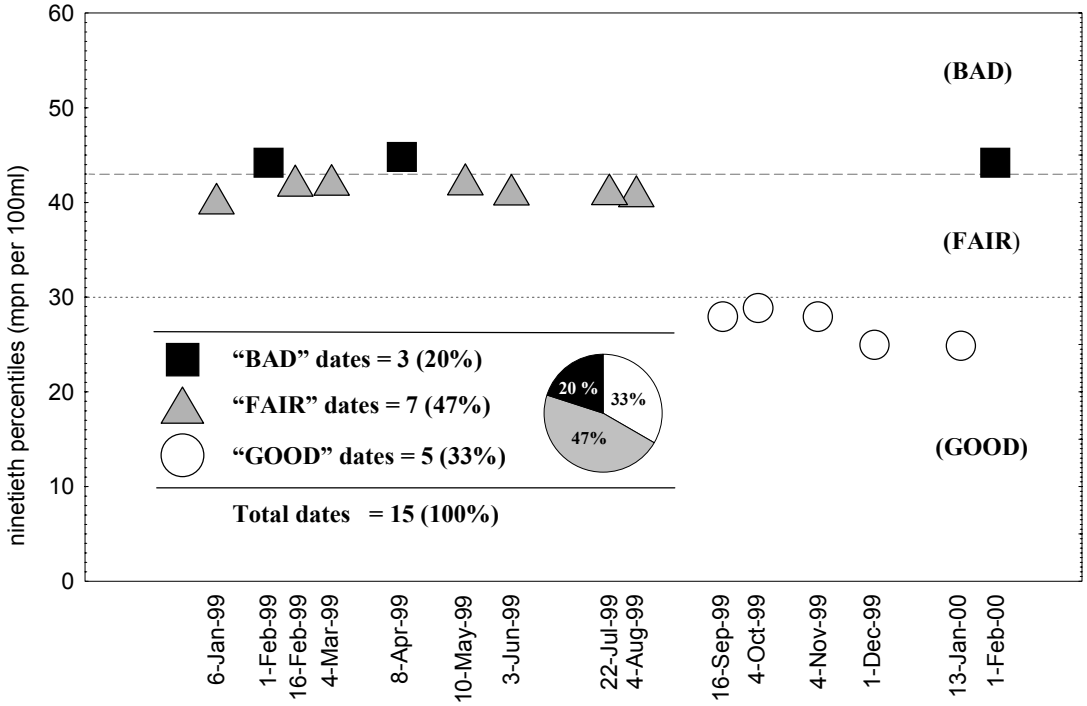
Figure METH-1. Method of determining growing area status using box plots of data pooled for each station in Henderson Inlet from January 1, 1999 through March 2000.



Ranking of Growing Areas: The rank of each growing area was determined by multiplying the percentage of stations in each category (GOOD, FAIR, and BAD) by a corresponding "weighting factor" (factor=1 to GOOD percentages; factor=2 to FAIR percentages, and factor= 3 to BAD percentages). Division of the sum of the weighted percentages by 100 produced a "Fecal Impact Index" for each area. The impact index ranges from 1.00 (all stations in GOOD category) to 3.00 (all stations in BAD CATEGORY). The ranking of growing areas by fecal impact indices are discussed in RESULTS (PUGET SOUND-WIDE) on page 9. Appendix C (page 80) contains a tabular summary of calculations of fecal impact indices.

Station Status: The first step in determining the status of an individual station was to plot ninetieth percentiles against sampling dates for the period from January 1999 through March 2000. (Figure METH-2 shows ninetieth percentiles from Station 3 in Henderson Inlet.) The ninetieth percentiles were then sorted into three groups: GOOD, FAIR, and BAD (as in Growing Area Status on page 7). Figure METH-2 shows that 5 of 15 ninetieth percentiles (33%) at Station 3 were GOOD, 7 (47%) were FAIR, and 3 (20%) were BAD. The pie chart summarizes the status of Station 3. The pie chart for each station can be visually compared to others in its growing area to show spatial patterns of impact (i.e., see Figure HNL-1 on page 57).

Figure METH-2. Method of determining station status using a plot of ninetieth percentiles versus date at Station 3 in Henderson Inlet (Jan 1, 1999-March 2000).



Station Trends: Temporal trends were determined at stations in growing areas categorized as less than GOOD (i.e., either FAIR or BAD; see **Growing Area Status**, page 7). Both statistics (geometric means and ninetieth percentiles) for each selected station were graphed against sampling dates. Visual inspections of graphs revealed evidence of temporal trend in ninetieth percentiles. A station was scored "**trend not determined**" if its record was shorter than three years long or the highest ninetieth percentile (the statistic selected for trends testing) was less than 10 MPN per 100ml. Trends were tested for statistical significance with two "nonparametric" statistical tests: Spearman's *rho* and Kendall's *tau* (STATISTICA, Statsoft, Inc., Sokal and Rohlf, 1969). The alternative hypothesis (a true trend existed) was accepted only if both tests rejected the null hypothesis (there is no significant trend). Graphs for individual stations are shown and trends discussed in sections for individual growing areas. Test results with critical values for all selected stations are tabulated in Appendix B on page 73.

RESULTS (PUGET SOUND-WIDE)

Status of Growing Areas. The status of fecal pollution in 43 growing areas examined this year is summarized in Figure RESULTS-1 as pie charts of percentages of stations categorized as GOOD, FAIR, and BAD within each growing area during the period from January 1999 through March 2000.

Ranking of Growing Areas. Seventeen of 43 growing areas (40%) had fecal pollution indices of 1.0 (i.e., all stations in the growing area categorized as GOOD; see Appendix C, page 80). These included four of 11 areas in Hood Canal and nine of 13 areas in the Main Basin. Impact indices for the remaining 26 growing areas (60%) are shown in Figure RESULTS-2. The most contaminated areas were South Skagit Bay (Index = 2.85), Drayton Harbor (Index = 2.83), Chico Bay in Dyes Inlet (Index = 2.57), and Filucy Bay in south Puget Sound (Index = 2.25). Likely pollution sources in all areas include failing on-site sewage systems and pasture drainage from upland watersheds. Sources in Drayton Harbor, Henderson Inlet, and Oakland Bay include contaminated urban stormwater among assorted nonpoint sources. Drayton Harbor may also receive fecal wastes from boats. Major fecal pollution into Portage Bay appears to be drainage from dairy operations along the Nooksack River.

Summary. Status was determined for 713 stations in 43 growing areas examined (Appendix C, page 80). There were 598 GOOD stations (4%), 59 FAIR stations (8%), and 56 BAD stations (8%). Temporal trends were determined on 225 stations in 26 shellfish growing areas (Appendix B on page 73). Fecal pollution increased significantly over time at 103 stations (46%). Fecal pollution decreased at 61 stations (27%). Fecal pollution was stable at another 27% of stations.

Figure RESULTS-1. Status of fecal coliform pollution in selected shellfish growing areas throughout Puget Sound and the Strait of Juan de Fuca.

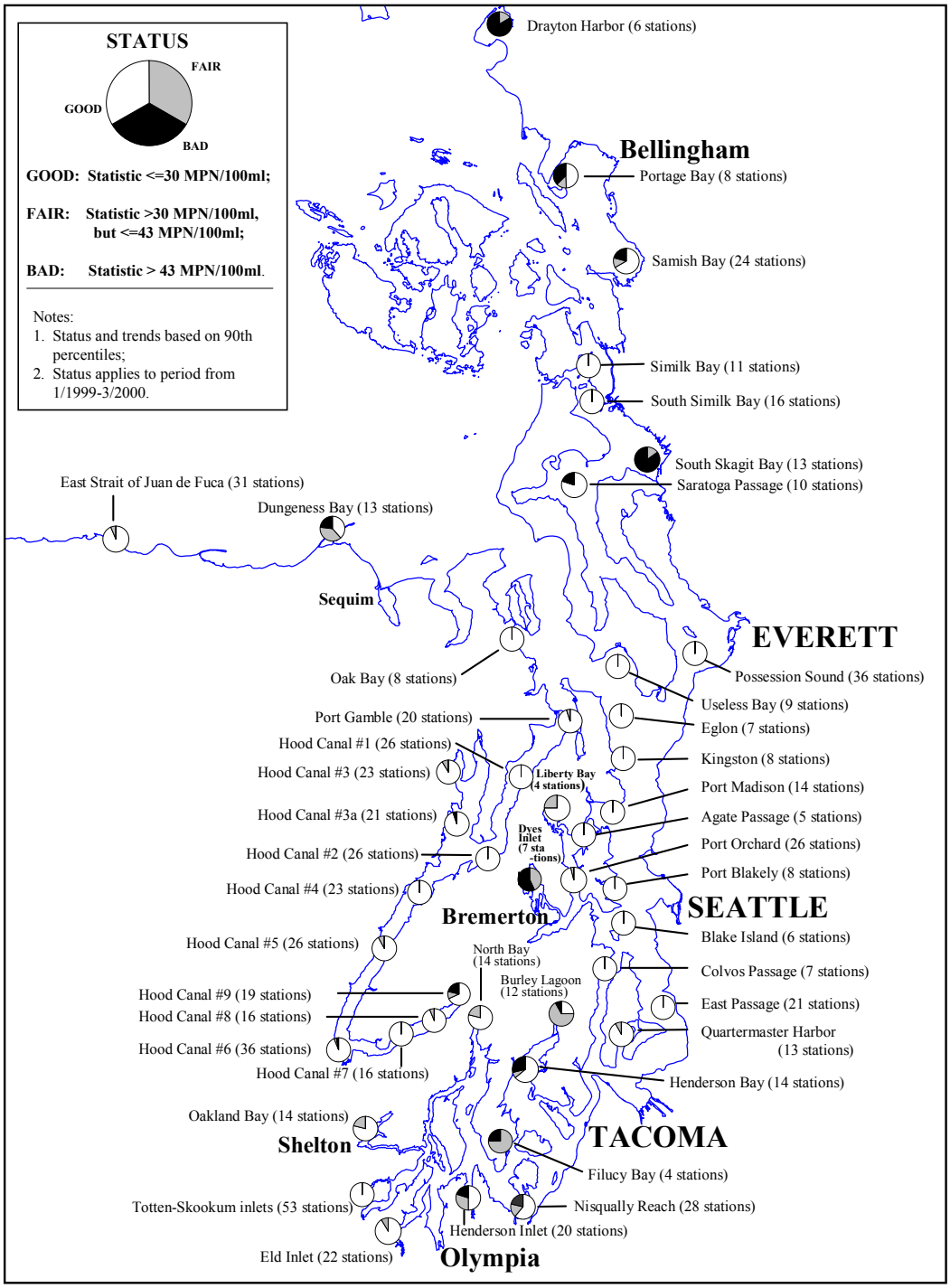
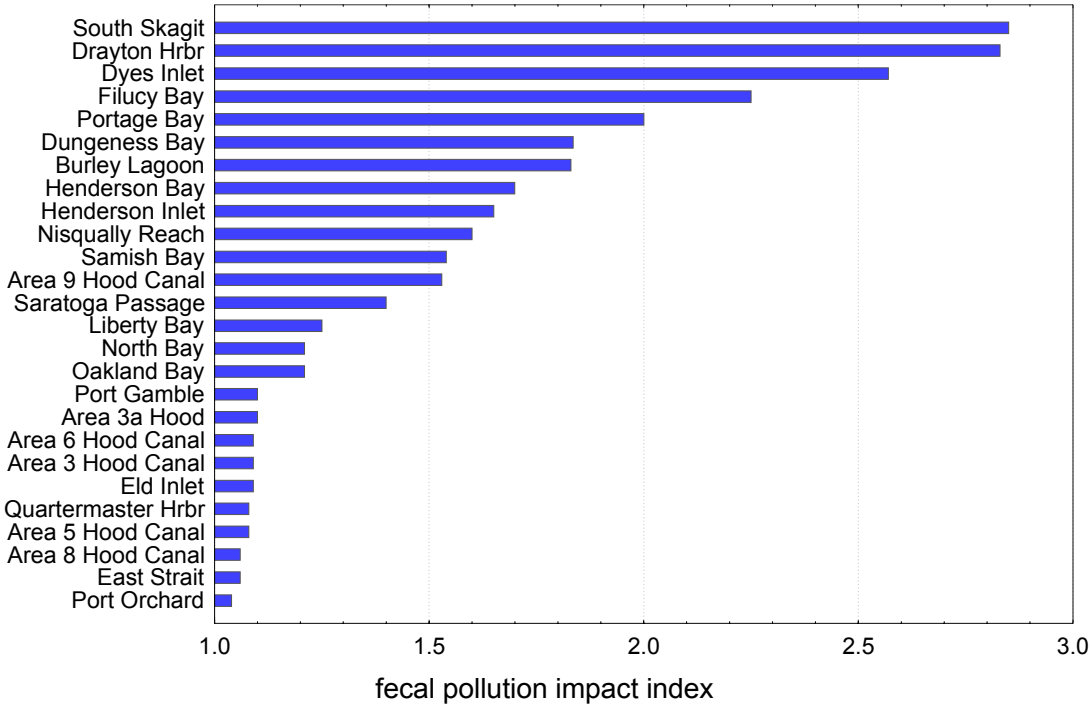


Table of Contents

Figure RESULTS-2. Ranking of shellfish growing areas according to fecal pollution impact.



RESULTS (INDIVIDUAL GROWING AREAS)

The remaining sections contain reports for 26 individual shellfish growing areas in Puget Sound that were impacted by fecal pollution (i.e., individual stations showed FAIR or BAD) in this year's analysis:

- **Strait of Georgia**: Drayton Harbor, Portage Bay, and Samish Bay.
- **North Puget Sound:** South Skagit Bay, and Saratoga Passage.
- **Strait of Juan de Fuca:** Dungeness Bay and East Strait (including Pysht River).
- **Hood Canal:** Port Gamble, and Hood Canal areas #3 (including Quilcene and Dabob bays), #3a (including Dosewallips), #5 (Lilliwaup), #6 (Annas Bay), #8, and #9 (Lynch Cove).
- **Main Puget Sound Basin:** Lemolo (Liberty Bay), Chico Bay (Dyes Inlet), Port Orchard, and Quartermaster Harbor (Vashon Island).
- **South Puget Sound:** Nisqually Reach, Filucy Bay, Henderson Bay (including Minter Bay), Burley Lagoon, Henderson and Eld inlets, Oakland Bay and North Bay.

Whatcom County

DRAYTON HARBOR

Background: In early 1995, DOH downgraded over 1000 acres of growing area in Drayton Harbor from **Approved** to **Prohibited**. Local interests and agencies have conducted remedial action programs, including repair of on-site sewage systems, planning and installation of agricultural best management practices, improved boat waste handling at the marinas, and an upgrade of Blaine's sewer system. These actions did not produce significant change in water quality. In 1999, DOH downgraded all of Drayton Harbor to **Prohibited**.

Status and Trends: Three stations on the east and one toward the south side of Drayton Harbor (stations 3, 4, 6, and 8) were categorized as **BAD** on all recent sampling dates (Figure DRT-1). Station 12 by the Semiahmoo Spit was less affected. A mid-bay station (Station 5) was least affected. Figure DRT-2 shows graphs for stations in Drayton Harbor. Four of six stations have become increasingly polluted over the years. The greatest pollution has occurred at Station 8 near the Port of Bellingham Marina (Figure DRT-2e). Fecal pollution statistics jumped markedly in 1999. Pollution has decreased since then, but the time has been too short to assess the significance of the drop.

Figure DRT-1. Status and Trends in fecal pollution in Drayton Harbor through March 2000.

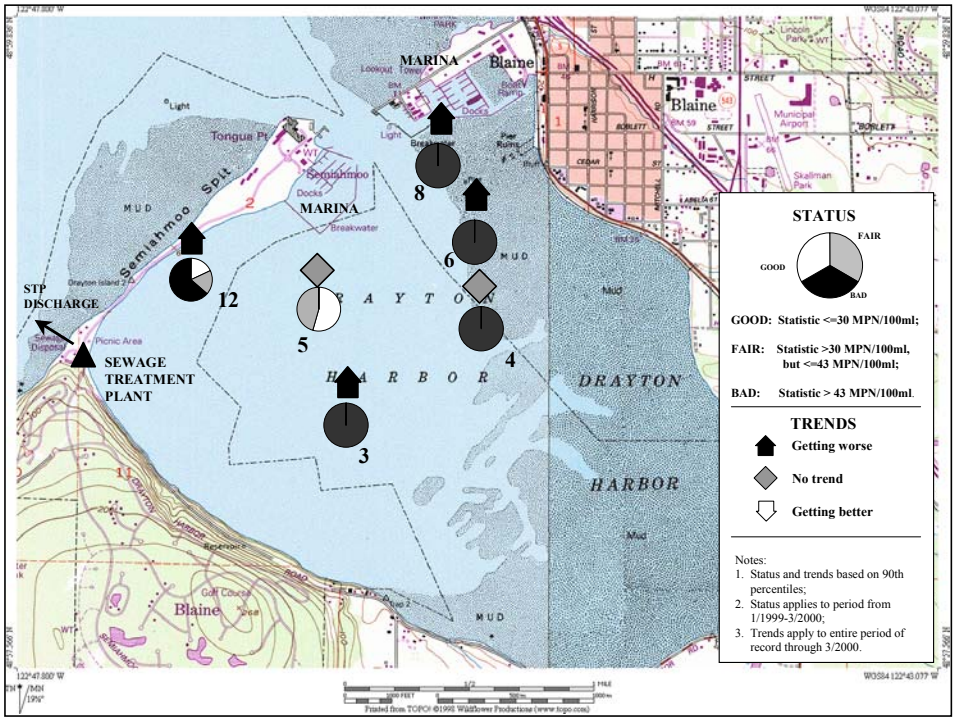
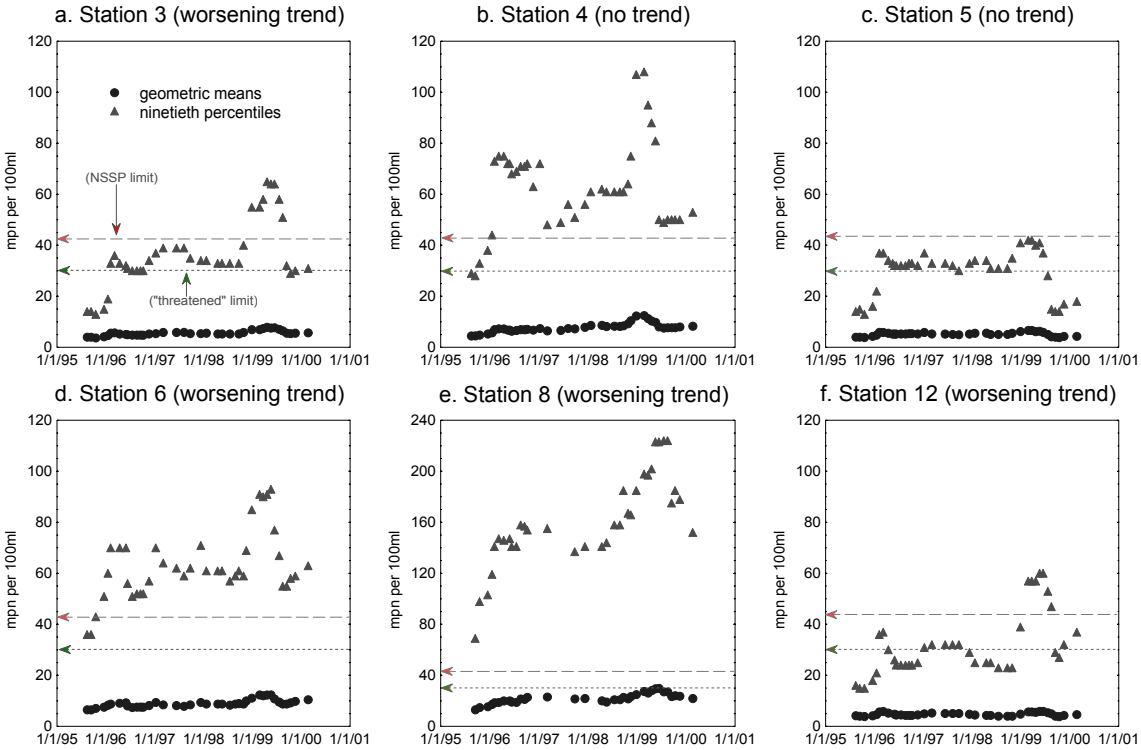


Table of Contents

Figure DRT-2. Fecal pollution over time in Drayton Harbor.



Whatcom County

PORTAGE BAY

Background: The Lummi Nation, a traditional shellfish harvester in Portage Bay, voluntarily ceased harvest in late 1996 due to increasing fecal pollution. DOH downgraded north Portage Bay to **Restricted** by mid-August 1997. Dairies along the lower Nooksack River were identified as the chief source. U.S. EPA Region 10 and the Washington State Department of Ecology have brought legal action against dairies for direct discharge of manure into the Nooksack River. DOH expanded the **Restricted** zone in the north in early 1999. The southern end of Portage Bay remains **Approved**.

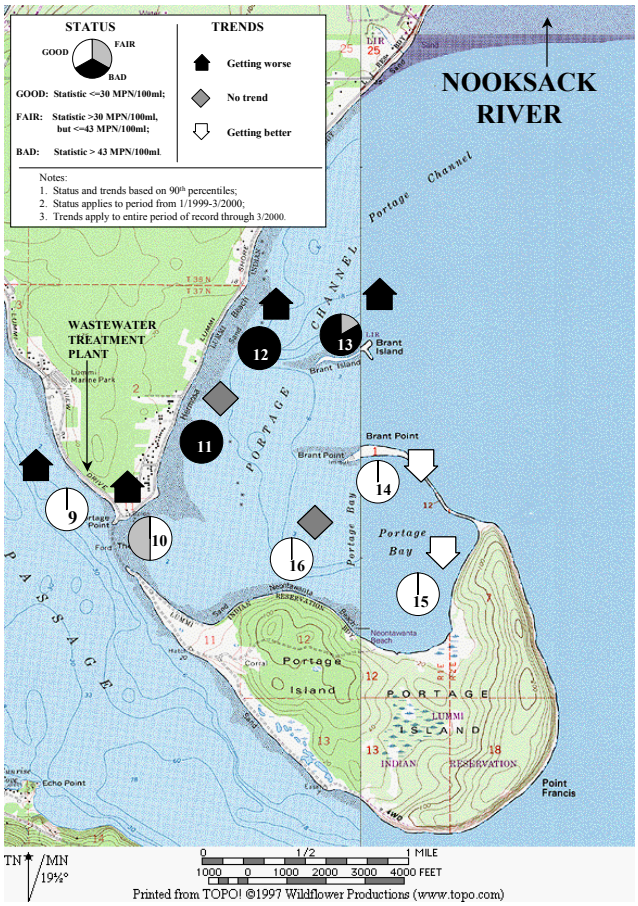


Figure PRT-1. Status and trends in fecal coliform pollution in Portage Bay through March 2000.

Status and Trends:

Three stations just north of Portage Island and Station 9 (near the Gooseberry Point treatment plant discharge) were **GOOD** during the current reporting period (Figure PRT-1). Stations 11 and 12 were **BAD** all the time. Wind-driven current may carry water from the Nooksack River southwest into Portage Channel. Two other stations had mixed outcomes. Four stations worsened. Station 11 and 16 did not change significantly. Figure PRT-2 shows graphs for selected stations. There may have been an overall reduction of fecal pollution through late 1998. Stations 14 and 15 show a slight but significant reduction. However, stations 10, and 12-13 show continual rise since then.

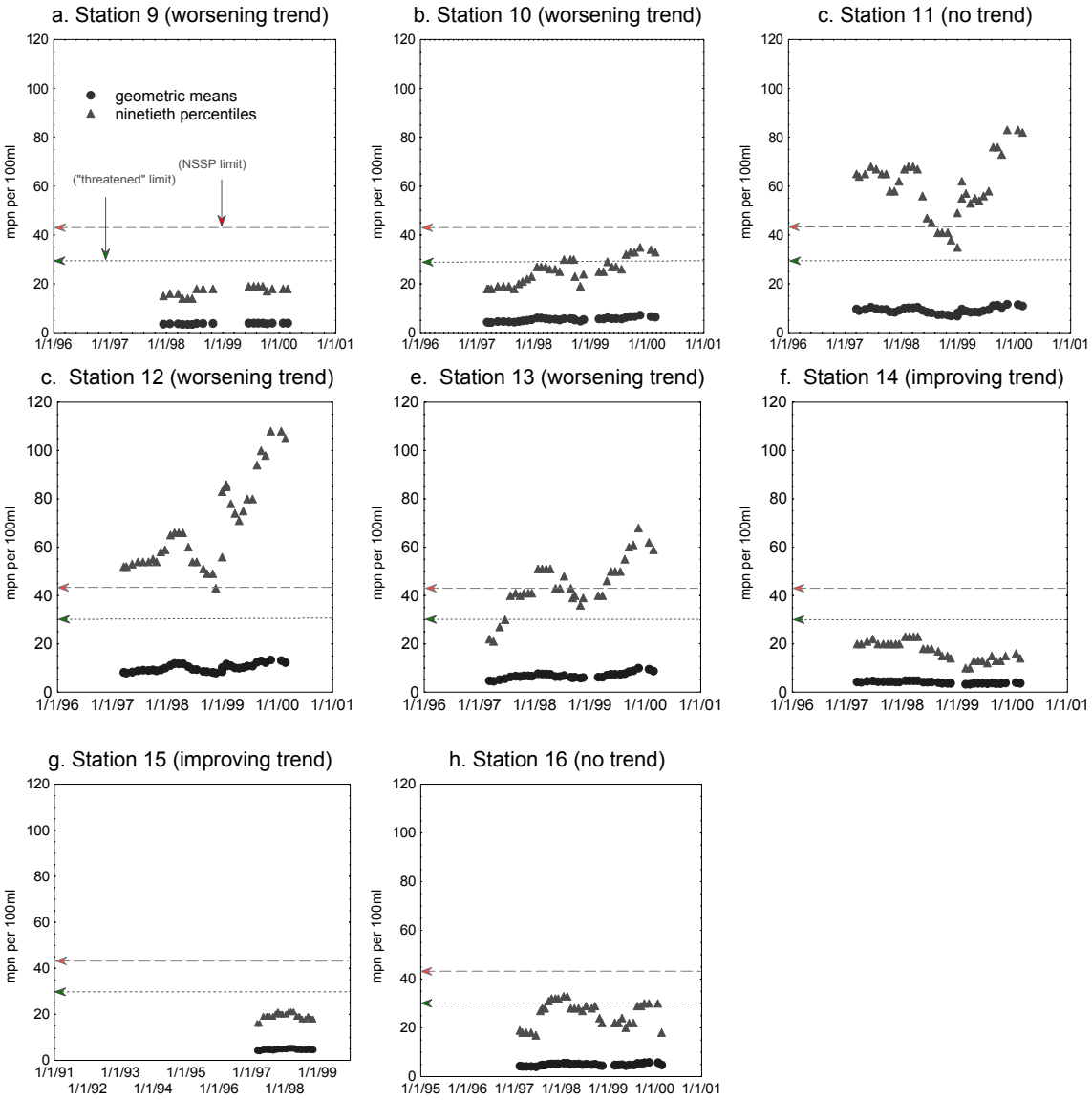


Table of Contents

Skagit County

SAMISH BAY

Background: In August 1994, nearly 25% of the harvest area in Samish Bay was downgraded to **Restricted** or **Prohibited**. Pollution sources included failed on-site sewage systems in Blanchard and elsewhere, raw sewage from Edison, and extensive pasture drainage. A sewage treatment system with ground disposal was built in Edison, and sewage discharges into Edison Slough were ended. Thirty on-site sewage systems were repaired in Blanchard. Nearly three miles of stream bank were fenced. In June 1998, about a third of the shellfish beds were upgraded.

Status and Trends: Fecal pollution is concentrated in the southwest end of Samish Bay (Figure SMS-1). Figure SMS-2 shows graphs of fecal pollution at selected stations. Stations 6-9 and 14 (northeast end of Samish Bay) significantly improved, perhaps due to repair of on-site sewage systems in Blanchard. But fecal pollution increased at stations 1, 15, 19 and 20 (southwest end of Samish Bay), perhaps due to agricultural wastes discharged through tide gates into the Samish River. Station 13 near Edison Slough has not yet changed, despite the new sewage system in Edison. Reduced pollution from Edison Slough may be obscured by the magnitude of pollution from the Samish River. Perplexingly, stations 18 and 19 show opposite trends, although the stations are adjacent.

Figure SMS-1. Status and trends of fecal pollution in Samish Bay through March 2000.

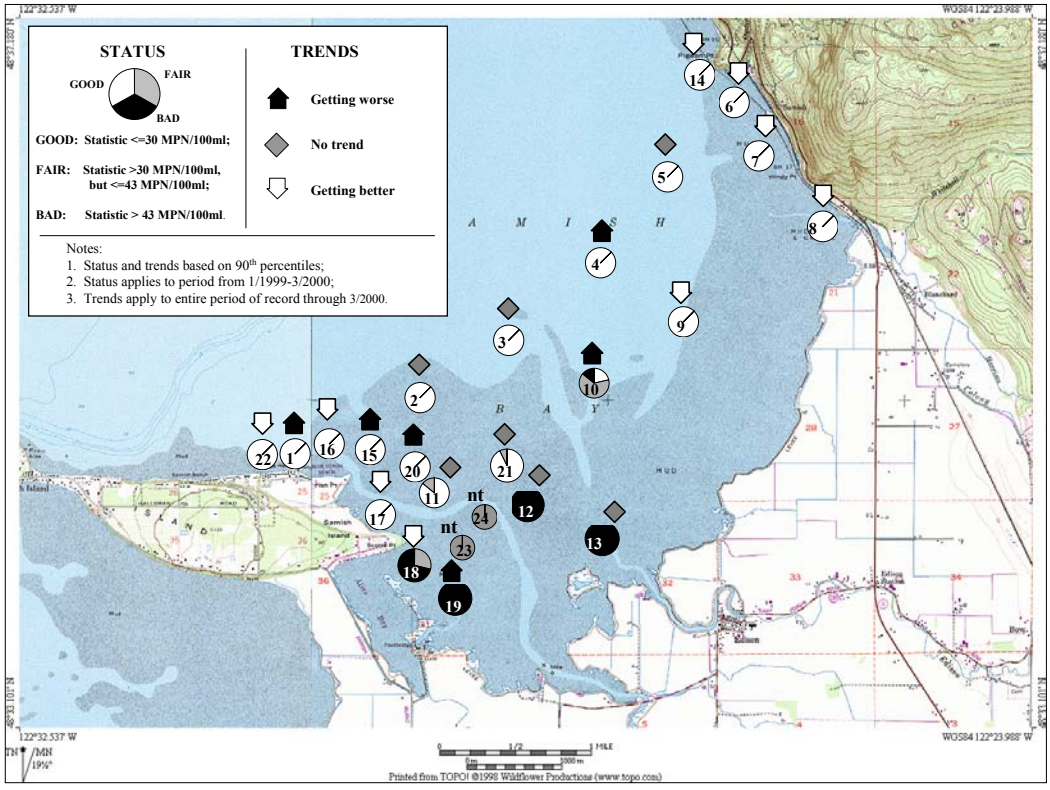


Table of Contents

Figure SMS-2. Fecal pollution over time in Samish Bay through March 2000.

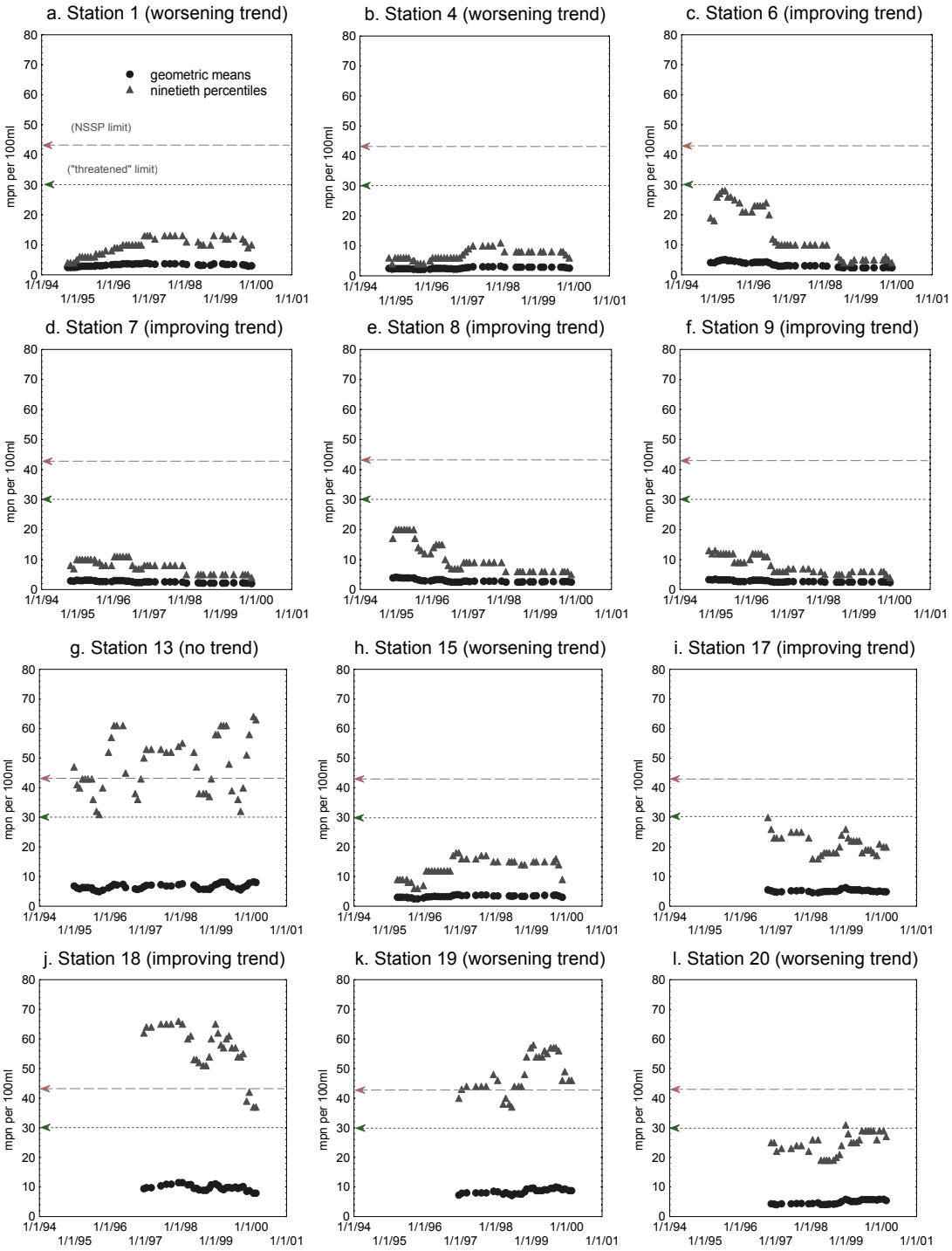


Table of Contents

Skagit and Snohomish counties

SOUTH SKAGIT BAY

Background: Nearly 6000 acres of shellfish grounds in south Skagit Bay were downgraded from **Approved** to **Restricted** in March 1987 largely due to rural nonpoint pollution. Over 9000 acres in north Skagit Bay were downgraded in 1989. In 1993, DOH upgraded over 2000 acres from **Restricted** to **Conditionally Approved** following an upgrade of the Stanwood Sewage Treatment Plant and control of agricultural sources along the Stillaguamish Slough.

Status and Trends: Figure SSK-1 indicates that the greatest impact from fecal pollution occurred at mid-bay stations 9, 10, 15, and 16. The apparent gradient westward from the mouth of the south fork of the Skagit River suggests the Skagit River is the major source of fecal pollution. Station 10 near the mouth of the south fork of the Skagit River increased the most rapidly (Figure SSK-2g) and was the most contaminated station. On the other hand, Station 1 (near the Stillaguamish Slough) has improved.

Figure SSK-1. Status and Trends in fecal pollution in south Skagit Bay through March 2000.

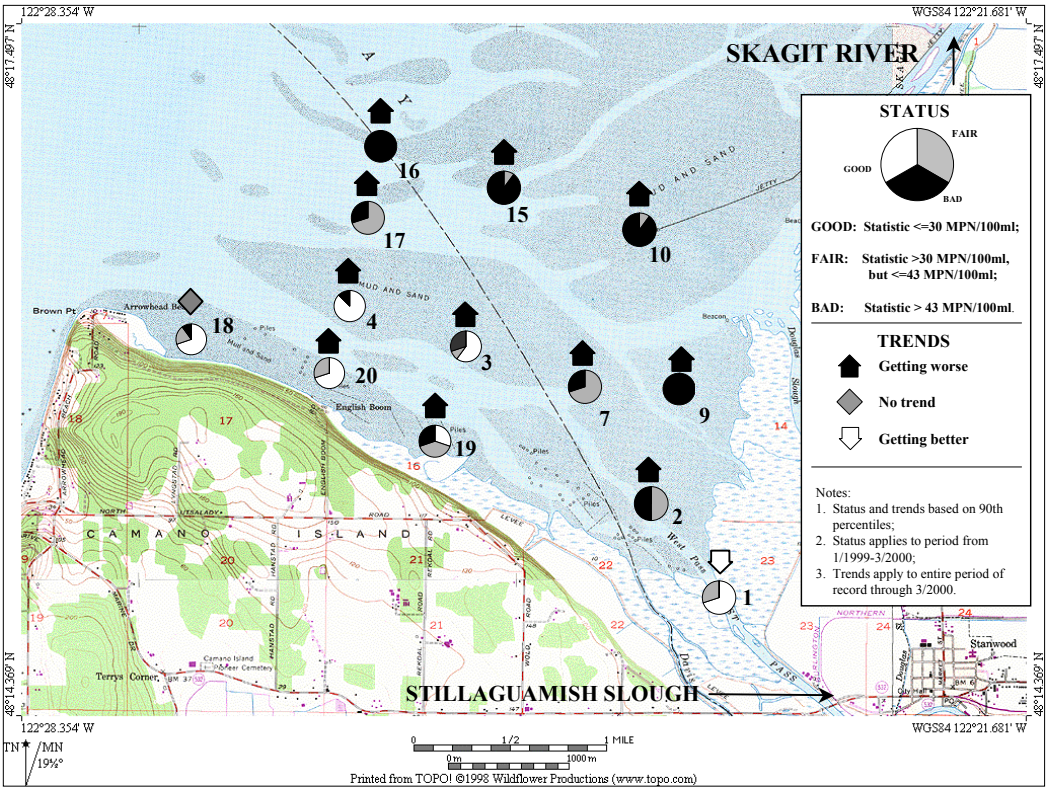


Table of Contents

Figure SSK-2. Fecal pollution over time in south Skagit Bay.

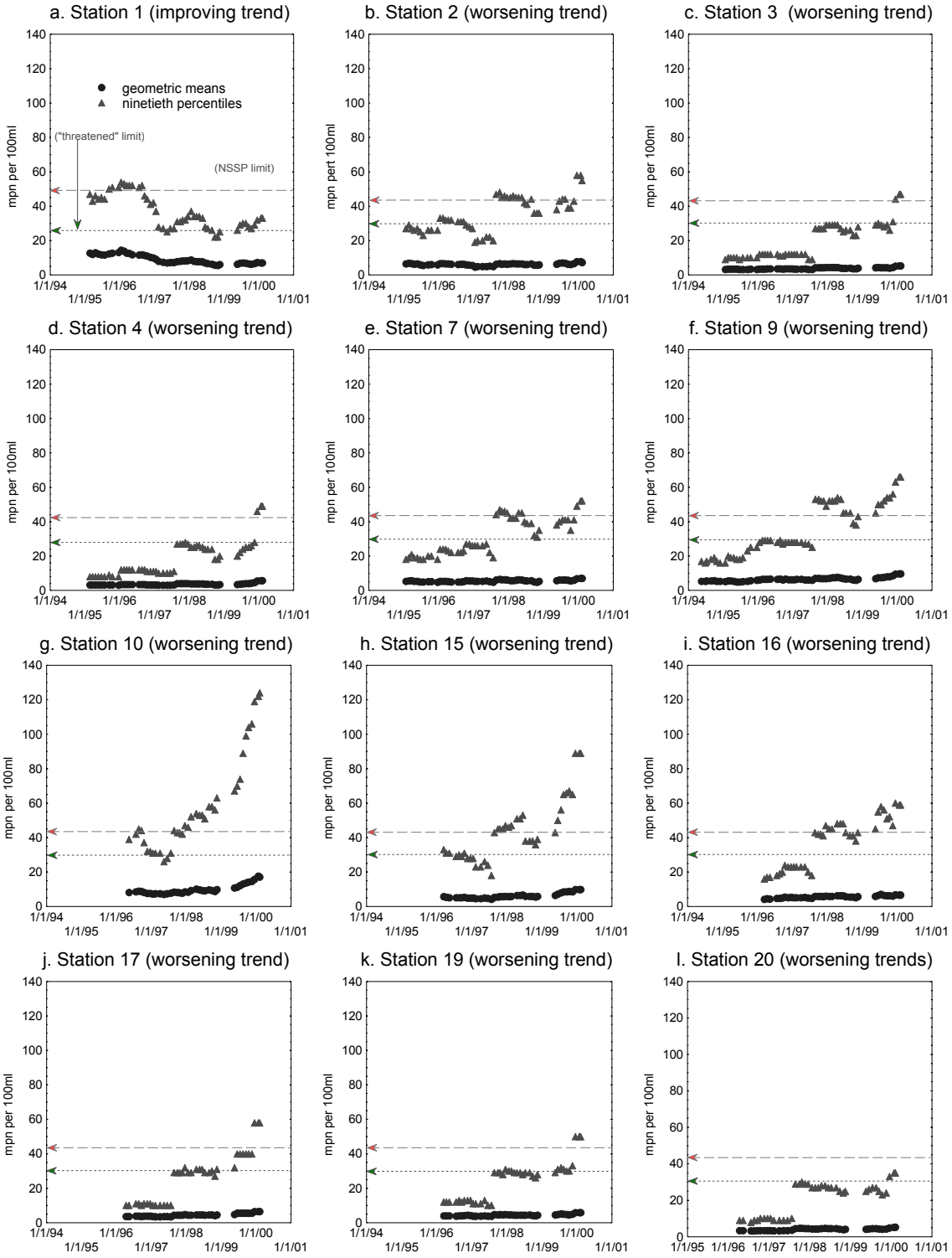
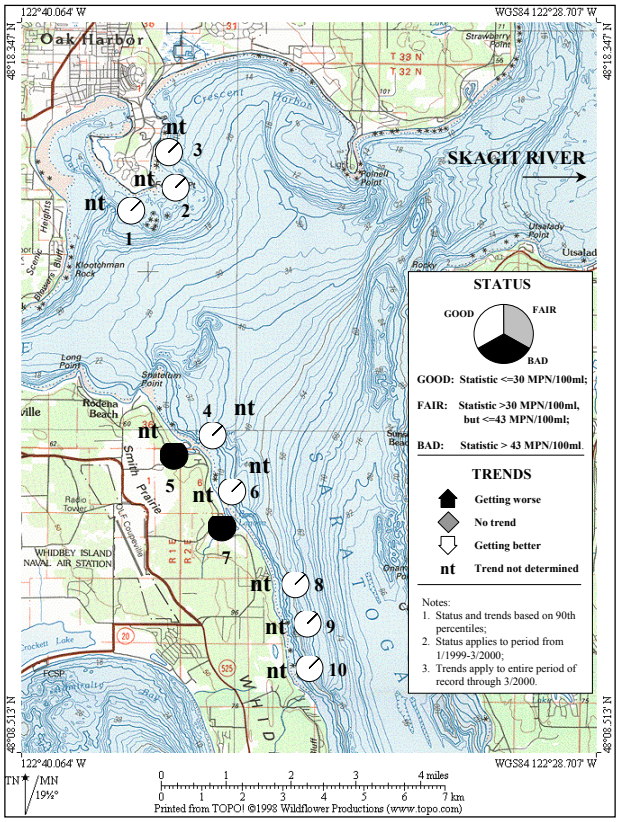


Table of Contents

Island County

SARATOGA PASSAGE

Background: DOH began a sanitary survey of Saratoga Passage in July 1996 following a request by the Skagit System Cooperative to evaluate previously unharvested shellfish grounds. DOH surveyed 76 on-site sewage systems along the marine shoreline. Fifteen systems along Harrington Lagoon and five in Race Lagoon within 50 feet of the shore were deemed "suspected" pollution sources. No direct discharges or failed systems were observed.



Status and Trends: Eight of ten stations were classified as **GOOD** during the recent period (Figure STG-1). Two stations were **BAD** (based on a single statistic calculated from limited data). Both **BAD** stations are located within Race and Harrington lagoons where pollution risk from localized shoreline sources is high and flushing is limited. Trends could not be determined, so graphs were not produced. Two growing areas in Saratoga Passage were classified Approved in May 2000. Harrington Lagoon was Prohibited.

Figure STG-1. Status and Trends in fecal pollution in Saratoga Passage through March 2000.

Clallam County

DUNGENESS BAY

Background: The Jamestown S'Klallam Tribe has farmed oysters in Dungeness Bay since 1965. Recreational harvesting also occurs in the inner bay. Water quality surveys in 1991-1992 revealed high fecal coliform levels in numerous watershed drainages. In 1996, DOH surveyed the shoreline and upland drainages. In 1997 local volunteers, Tribal and County staff began joint water monitoring. Elevated fecal counts continued to occur throughout Dungeness Bay. In November 1999, the Department of Ecology started a study to determine the total maximum daily load (TMDL) for pollutants into Dungeness Bay. In April 2000, DOH downgraded 300 acres of Dungeness Bay to **Prohibited**. The downgrade triggered Closure Response planning required under the Puget Sound Water Quality Management Plan. DOH expanded the closure zone in April 2001.

Status and Trends: Five of 13 stations in Dungeness Bay were **GOOD** during the current reporting period (January 1999 through March 2000). Station 11 near the mouth of the Dungeness River was **BAD** all the time (Figure DNG-1). The spatial pattern in Figure DNG-1 suggests a gradient of reduced pollution from the river mouth into the inner bay. All but 2 of the 13 stations showed increasing trend in fecal pollution for the period of record (mid-1996 through March 2000.) Figure DNG-2 shows graphs for most stations in Dungeness Bay. Stations 11, 2 and 3 (closest to the mouth of the Dungeness River) were the most polluted among all stations. Station 11 (figure DNG-2b) continuously exceeded the NSSP limit since early 1997.

Figure DNG-1. Status and Trends in fecal pollution in Dungeness Bay through March 2000.

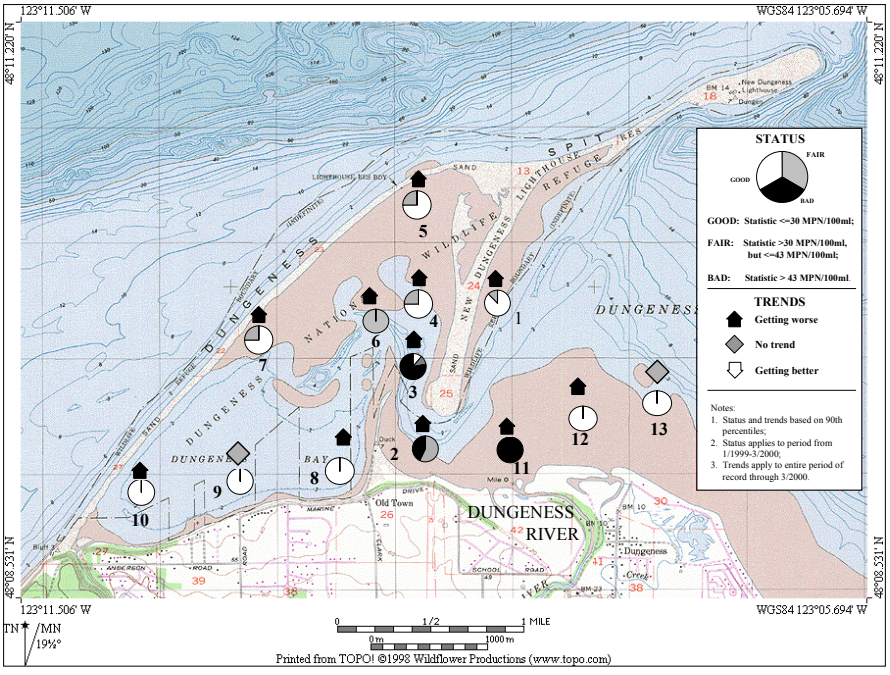


Table of Contents

Figure DNG-2. Fecal pollution over time in Dungeness Bay.

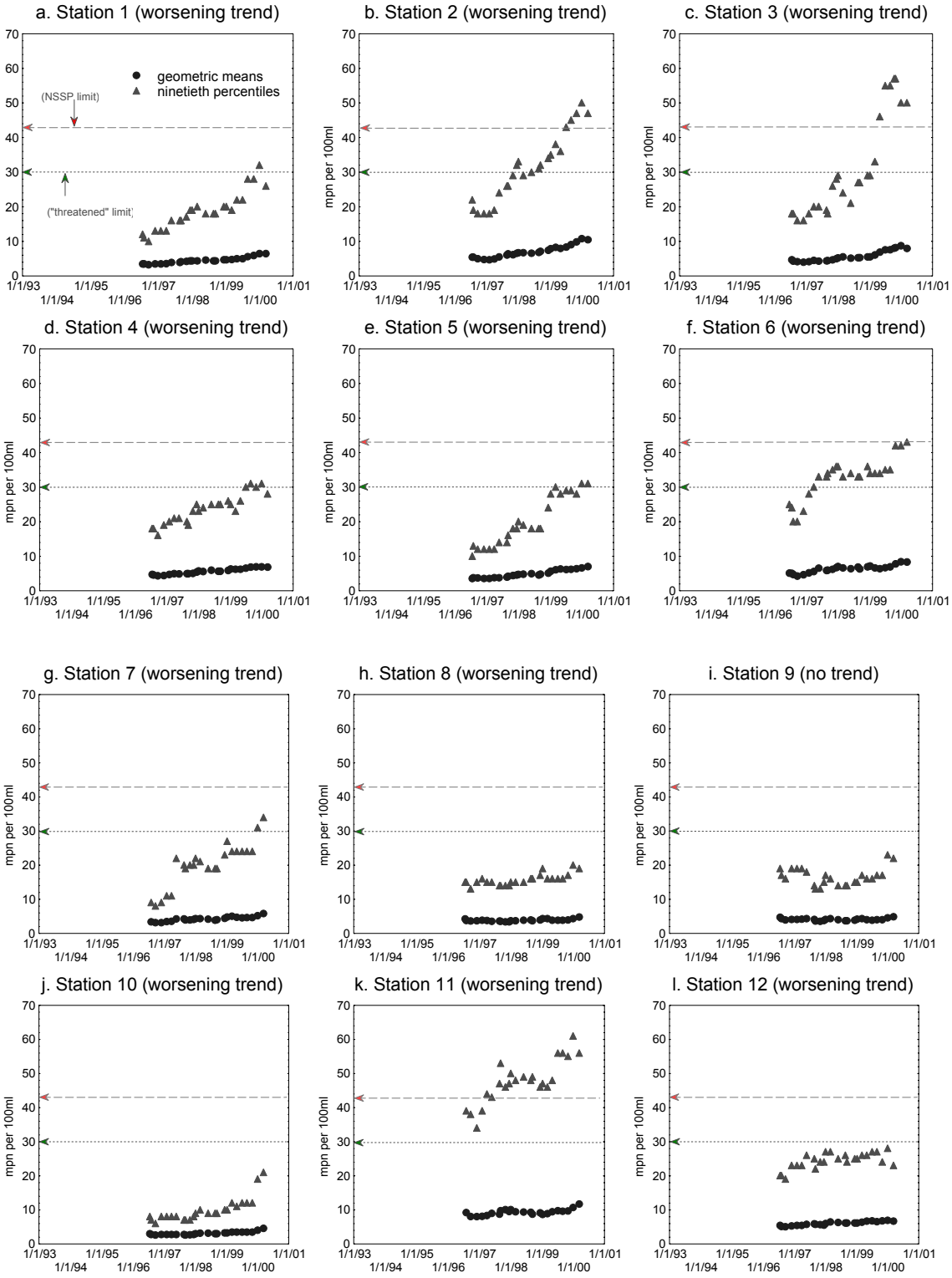


Table of Contents

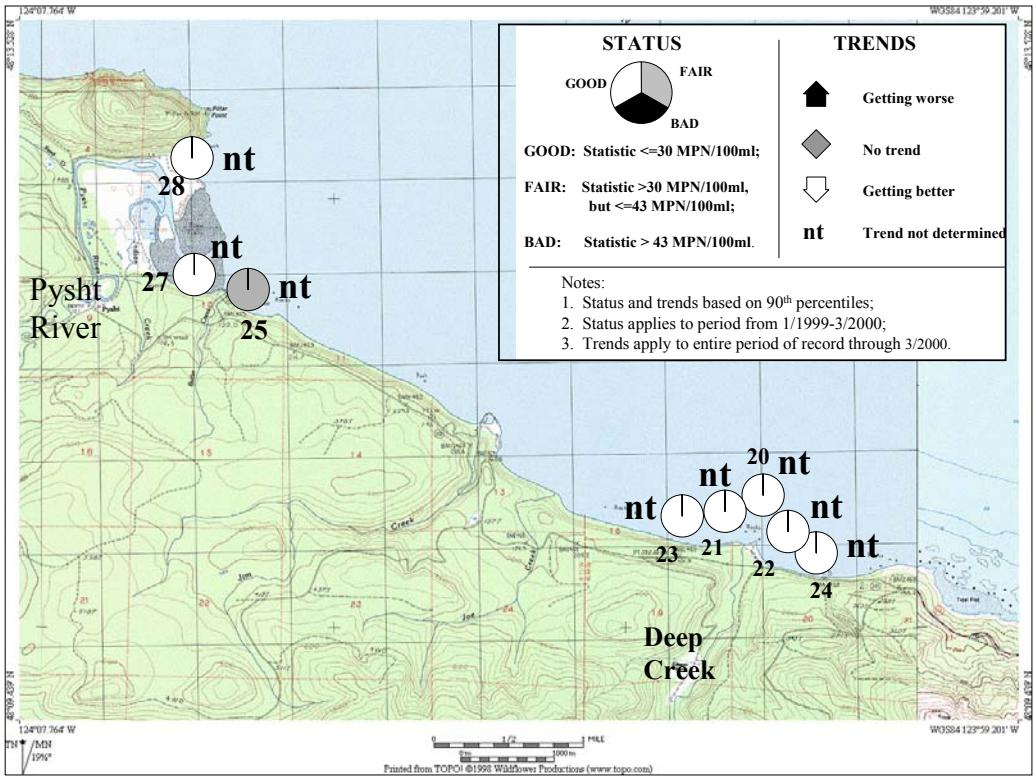
Clallam County

EAST STRAIT OF JUAN DE FUCA (PYSHT RIVER)

Background: In August 1996, DOH began a certification process at the request of the Lower Elwa S'Klallam Tribe for five growing areas along a 40-mile stretch of the Strait of Juan de Fuca from Dungeness Bay west to the Pysht River. DOH and the Tribe began a cooperative sampling program. In 1998, following a sanitary survey, the Pysht River and Deep Creek area were classified **Approved**. However, a series of high fecal coliform results in late 1998 induced DOH to place Pysht River on its list of "Threatened" areas under its Early Warning Program (page 5). Additionally, since shellfish harvest is not imminent, the area is currently considered INACTIVE.

Status and Trends: Twenty-nine of 31 stations in the area were **GOOD** during the current reporting period. However, Station 25 near the mouth of Pysht River was **FAIR** due to a statistic that exceeded the **Threatened** criterion (30 MPN per 100ml) caused by high fecal coliform levels in a series of samples collected in late 1998. The period of record for East Strait of Juan de Fuca was too short to permit trend analysis. Therefore, no graphs were produced.

Figure PYS-1. Status in fecal pollution in East Strait of Juan de Fuca near Pysht River through March 2000.



Kitsap and Jefferson counties

PORT GAMBLE

Background: Historically, the Port Gamble growing area included the Olympic Peninsula shoreline from Port Ludlow to the Hood Canal Floating Bridge in addition to Port Gamble (the Bay) and adjacent Kitsap Peninsula shoreline. The Port Gamble S'Klallam tribe harvests shellfish in Port Gamble. In July 1996, DOH downgraded about 20 acres of growing area in Cedar Cove in the south end of Port Gamble. Likely sources were failed on-site sewage systems and agricultural practices in the Cedar Creek drainage. Sixteen failed on-site sewage systems were repaired and several small farms installed pollution controls. In April 1999, the Cedar Cove area was upgraded to **Approved**.

Status and Trends: Figure PRG-1 indicates that all stations in the Port Gamble were **GOOD** except one. Station 15 (Cedar Cove) was **BAD** on five of eight dates sampled from January 1, 1999 through March 2000 and **FAIR** on the other three. Only stations 14 and 15 had sufficiently high ninetieth percentiles (above 10 mpn per 100ml) and long enough records to justify trend analysis: Both stations showed upward trends (figure PRG-2). Station 15 in Cedar Cove rose slightly above the NSSP criterion since the upgrade.

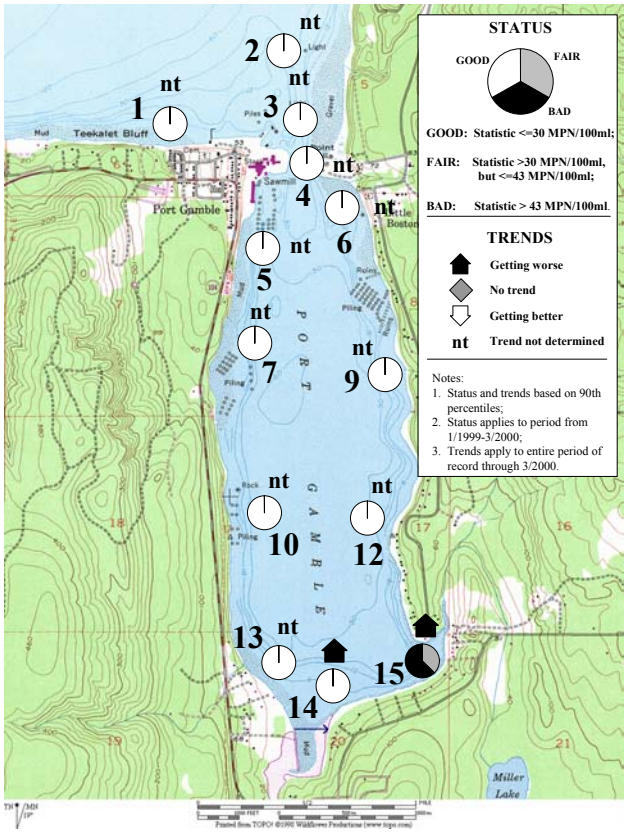
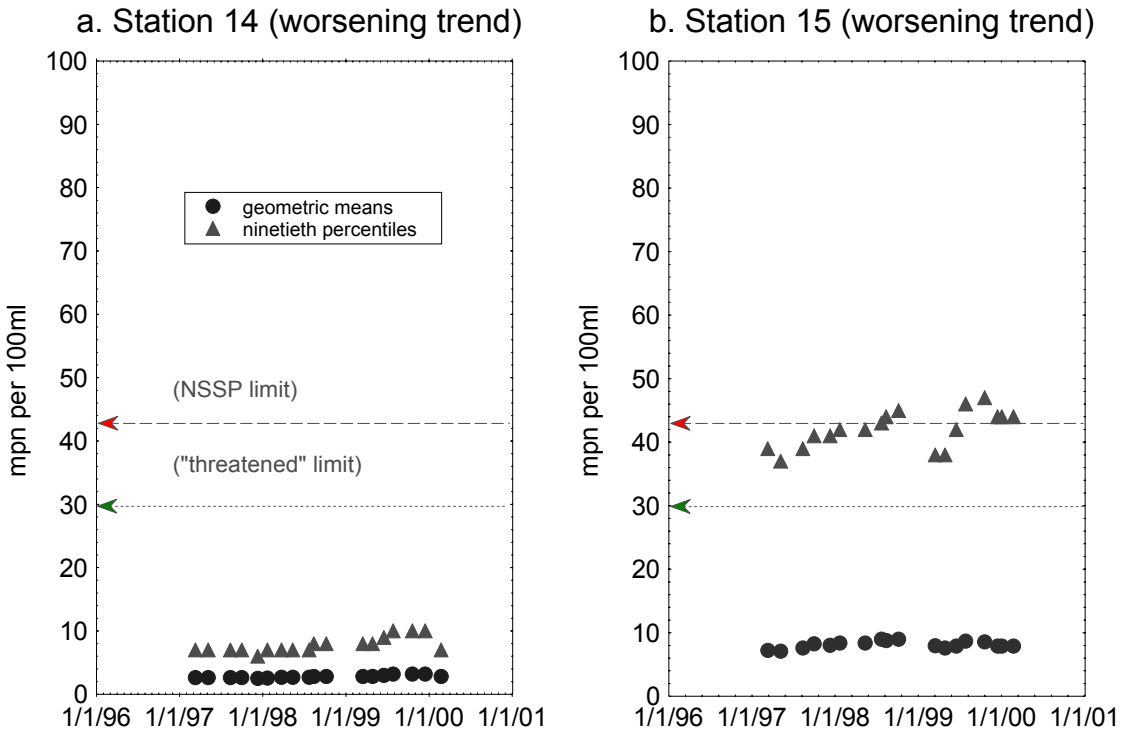


Figure PRG-1. Status and trends in fecal pollution in Port Gamble (Hood Canal) through March 2000.

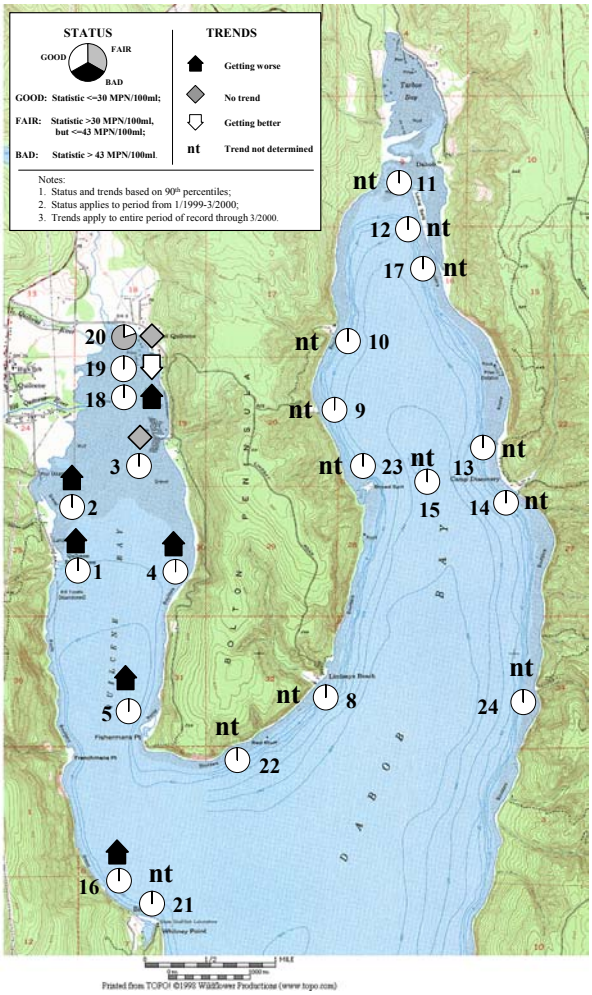
Figure PRG-2. Fecal pollution over time in Port Gamble



Jefferson County

QUILCENE AND DABOB BAYS (HOOD CANAL AREA 3)

Background: In 1984, 200 acres in the northern end of Quilcene Bay were downgraded from **Approved** to **Prohibited** due to failed on-site sewage systems, farm management practices, and populations of harbor seals in the innermost end of the bay. In the late 1980s, harbor seals were displaced when the log booms used for haul-out were taken from the water. Harbor seals continue to haul out on a raft at the entrance of Quilcene Bay near Station 5. Remedial programs over the years include locating and repairing failed on-site sewage systems, and improvement of farm practices. These programs were based on voluntary action. A DOH shoreline survey in 1995 recommended that the classification of 1984 be retained. In January 2001, DOH set a seasonal (May-September) closure zone around the Quilcene marina.



Status and Trends: The innermost station in Quilcene Bay (Station 20) was **FAIR** on most dates. All 22 other stations in Area 3 were **GOOD** on all occasions. Trends were determined on nine stations (all within Quilcene Bay). Six showed increasing trend, 1 decreased, and 1 was stable. The remaining stations had statistics that were too low to warrant trend analysis. Graphs of selected stations in Quilcene Bay are in Figure HD3-2.

Figure HD3-1. Status and trends in fecal pollution in Quilcene and Dabob bays through March 2000.

Figure HD3-2. Fecal pollution over time in Quilcene Bay

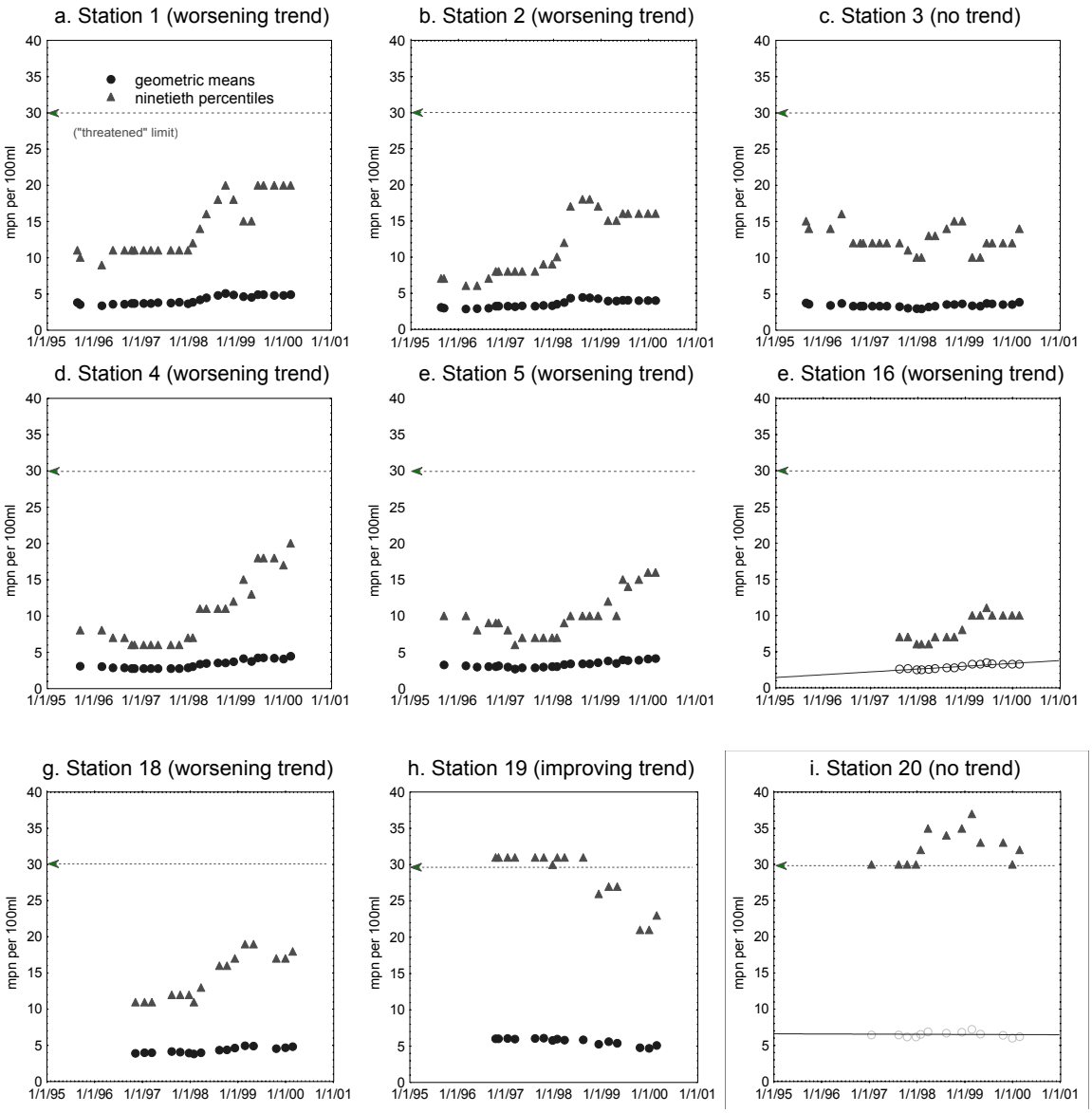
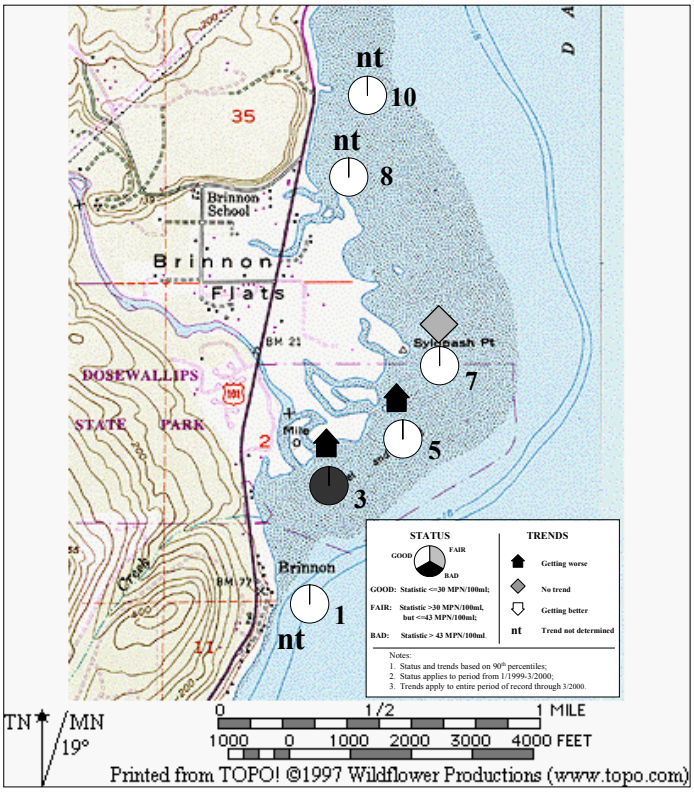


Table of Contents

Jefferson County

DOSEWALLIPS RIVER DELTA (HOOD CANAL AREA 3A)

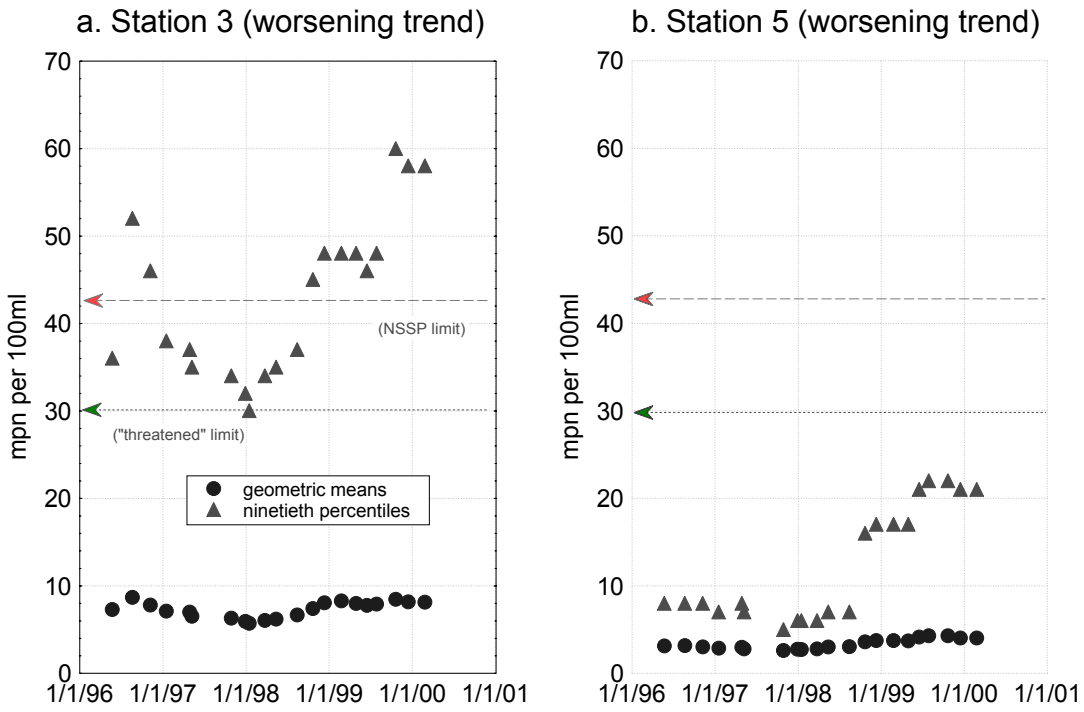
Background: In 1989, DOH reported very high fecal coliform levels in a slough used by harbor seals for hauling out of the water. Shellfish beds on the Dosewallips River delta were downgraded to **Restricted**. In June 1992, Dosewallips State Park authorities fenced off the mouth of the slough, and built a floating haul-out in deep water off the mouth of the Dosewallips River. Fecal pollution declined at the northern stations as a result of the exclusion of seals from the slough. DOH upgraded 30 acres on the north side of the delta to **Approved** in 1994.



Status and Trends: Twenty-one stations were evaluated in Hood Canal Area 3A. The status of 20 stations was **GOOD** during the current reporting period. One station (Station 3 near Dosewallips River mouth) was **BAD** on all occasions. Trends were determined at two sites; stations 3 and 5 near Dosewallips Delta (see Figure HD3a-1). Both sites showed upward trends (Figure HD3a-2). Data were too few or too low at the remaining sites for meaningful trends.

Figure HD3A-1. Status and trends in fecal pollution at Dosewallips River Delta through March 2000.

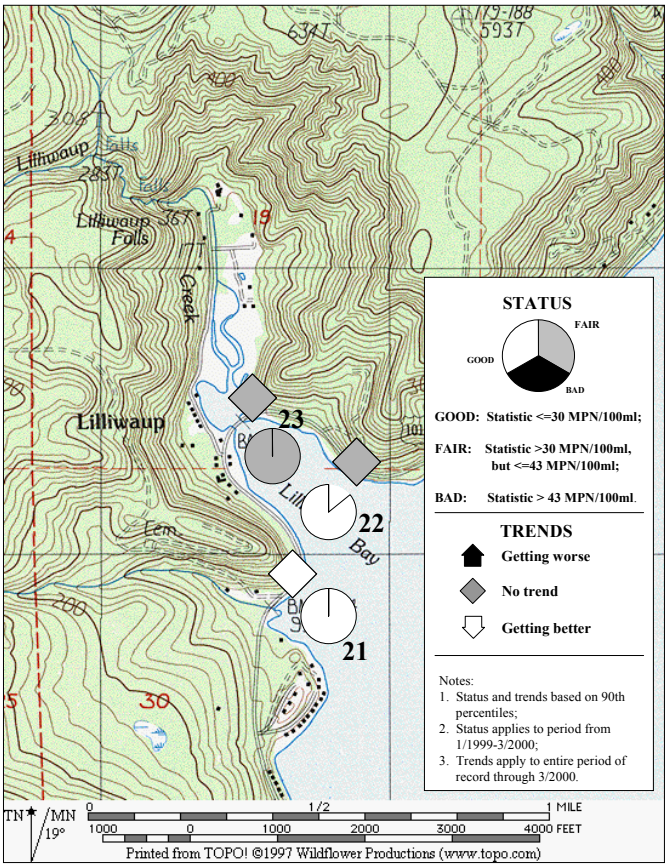
Figure HD3A-2. Fecal pollution over time at Dosewallips Delta.



Mason County

LILLIWAUP BAY (HOOD CANAL AREA 5)

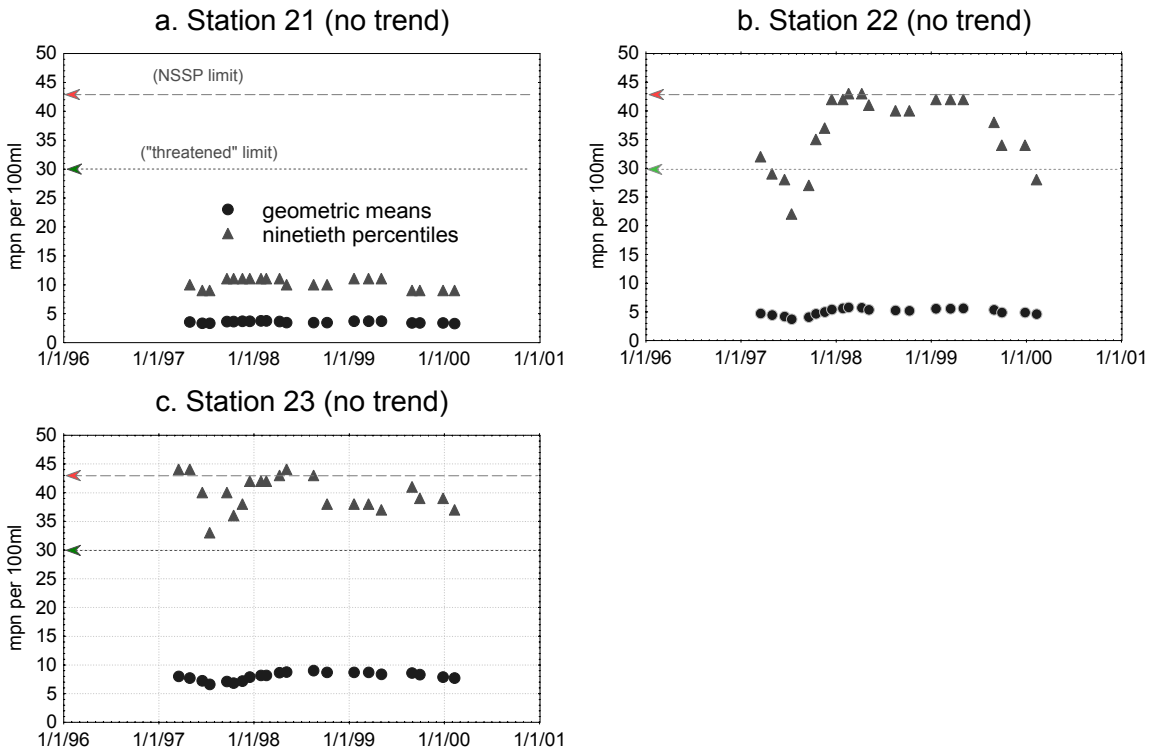
Background: In early 1997, as a result of increased fecal coliform pollution, shellfish growers voluntarily stopped harvesting in Lilliwaup Bay. The Mason County Health Department carried out sanitary surveys along the shoreline. DOH and the Washington State Department of Ecology expanded sampling to include the associated upland watershed. An Ecology study in 1999 concluded that in the wet season, most fecal pollution came from private lands and wildlife. Identification of dry-season sources required more work. Lilliwaup Bay was downgraded from **Approved** to **Prohibited** in September 1998.



Status and Trends: Twenty-six stations were evaluated in Area 5. The status of 24 stations was **GOOD** during the current reporting period (January 1999 through March 2000). During this period, two stations (stations 22 and 23) near Lilliwaup Bay were **FAIR** on most occasions (see Figure HD5-1). Long-term trends were analyzed for stations 21, 22, and 23. These sites showed no significant change (Figure HD5-2). Data at the remaining sites were too few or too low for meaningful trends.

Figure HD5-1. Status and trends in fecal pollution at Lilliwaup Bay through March 2000.

Figure HD5-2. Fecal pollution over time at Lilliwaup Bay (Hood Canal 5)



Mason County

ANNAS BAY-TAHUYA (HOOD CANAL AREA 6)

Background: In late 1995, DOH began emergency closures of Annas Bay when flooding occurred on the Skokomish River. DOH conducted shoreline surveys at Ayres (also known as Bald) Point (late 1993), Hoodsport (mid-1997), Annas Bay (late 1997), and Tahuya (early 1999). Sources noted included suspected failed on-site systems, gray-water discharges, an 80-acre horse ranch (in Tahuya) and four small marinas in Hoodsport and Union. Small **Prohibited** zones surround the marinas. The remainder of Area 6 is **Approved**.

Status and Trends: Thirty-six stations were evaluated. The status of 34 stations was **GOOD** during the current reporting period (January 1999-March 2000). Station 5 (near the mouth of the Skokomish River) was **FAIR** on most occasions. Station 27 (at the mouth of Tahuya Bay) was nearly equally split **GOOD**, **FAIR**, and **BAD** (Figure HD6-1). Eight sites met the criteria for analyzing trends (Figure HD6-1). Station 5 had a record that was too short to justify trend analysis. Two sites west of Tahuya Bay (stations 25, 26) showed significant increase; the remainder showed no significant trends. Graphs of selected stations are in Figure HD6-2.

Figure HD6-1. Status and trends in fecal pollution in Annas Bay and Tahuya (Hood Canal Area 6) through March 2000.

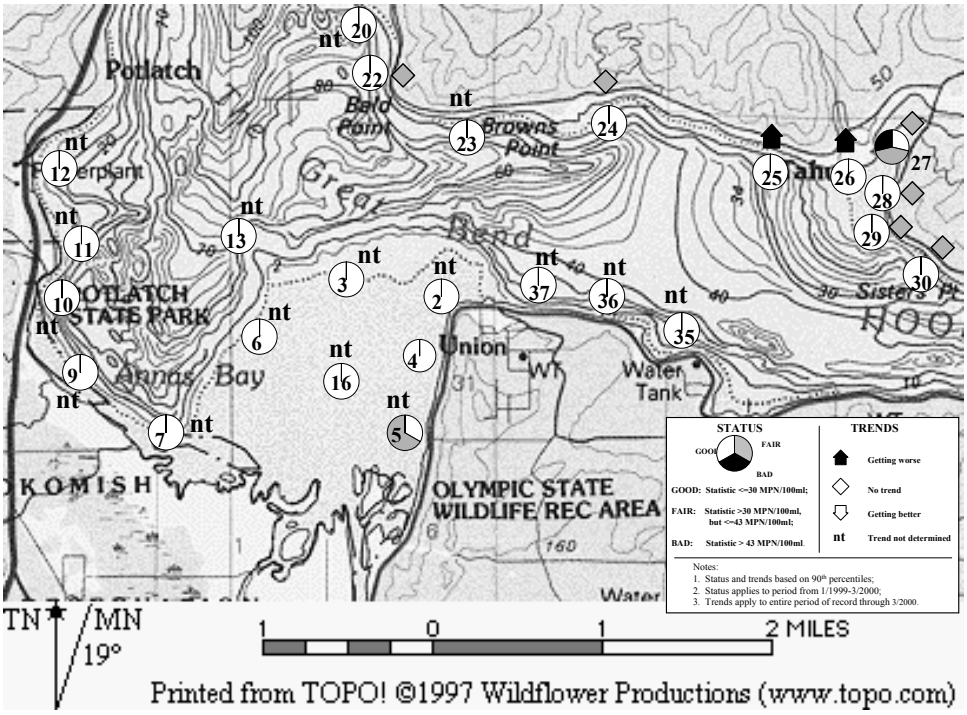
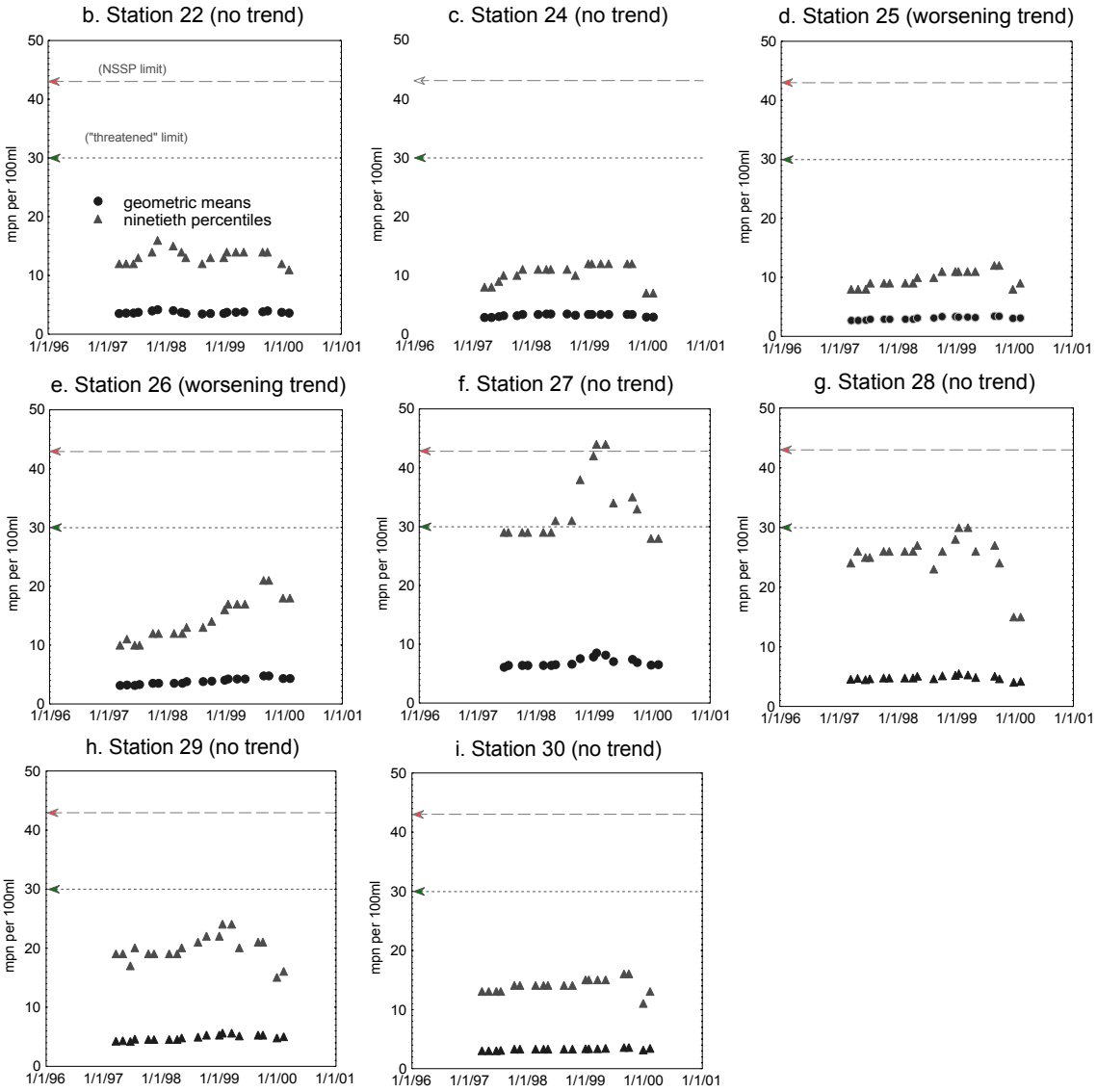


Table of Contents

Figure HD6-2. Fecal pollution over time in Annas Bay and Tahuya (Hood Canal Area 6)



Mason County

HOOD CANAL AREA 8

Background: DOH conducted a shoreline survey in Hood Canal Area 8 in 1993. They found that over 60% of the 562 shoreline homes are seasonal. Many are built over tidelands on fill dirt placed behind bulkheads. On-site sewage systems (usually installed behind the bulkheads) may limit treatment effectiveness. The area surrounding Twanoh State Park is closed to shellfish harvest from May through the end of September because of boat traffic. The remainder of Area 8 is classified **Approved**.

Status and Trends: Fifteen of 16 stations were **GOOD** during the recent period (January 1, 1999-March 31, 2000). Station 3 near Forest Beach (Figure HD8-1) was **FAIR** about a quarter of the time and **GOOD** the remainder. Eight stations had statistics high enough to warrant trends analyses. Five sites showed no significant change. Two stations near Twanoh State Park (stations 2 and 16) showed a worsening trend, while Station 11 improved. Graphs for each "trend" station are in Figure HD8-2.

Figure HD8-1. Status and Trends in fecal pollution in Hood Canal Area 8 through March 2000.

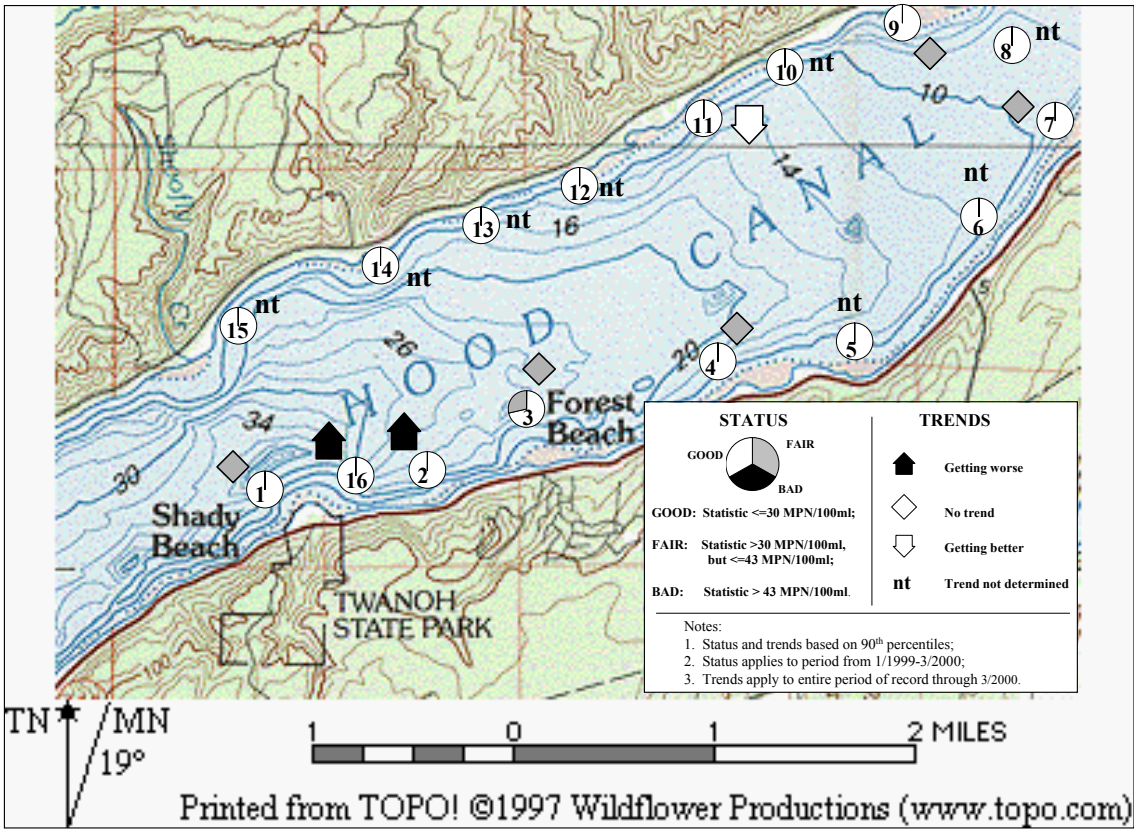
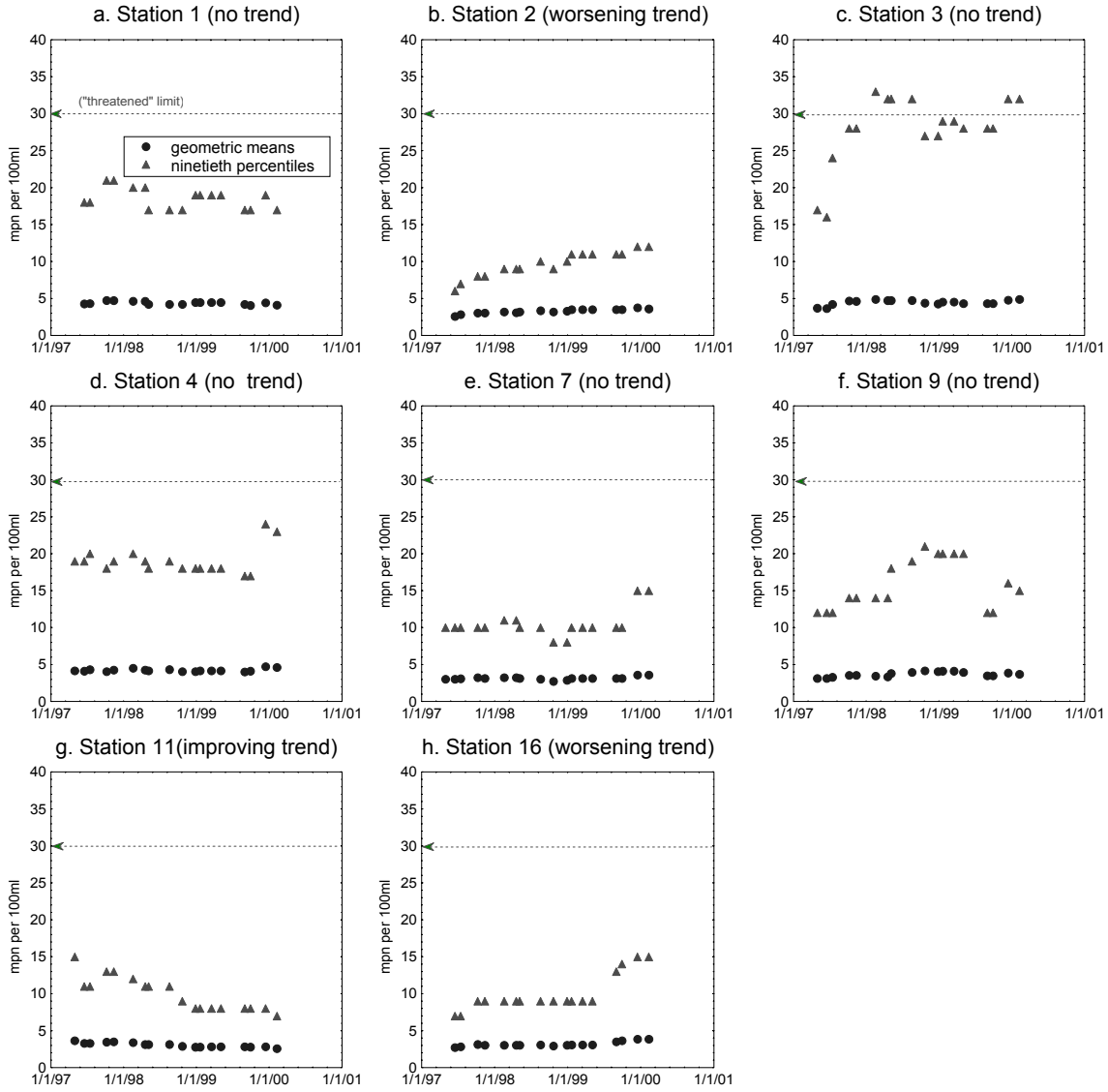


Figure HD8-2. Fecal pollution over time in Hood Canal Area 8.



Mason County

HOOD CANAL AREA 9

Background: DOH classified all of Hood Canal Area 9 (Lynch Cove) **Prohibited** in 1993. Later, 570 acres of growing area along the south shore were classified "**Restricted**" to allow relay of shellfish to **Approved** waters. In late 1996, DOH upgraded 500 acres of the **Restricted** area to **Approved** following the finding and repair of failed on-site sewage systems by Mason Country. Similar action along the north shore resulted in an upgrade of part of the north shore to **Approved**. A recent survey done by DOH and Mason County discovered no new fecal sources along the **Approved** shoreline. However, significant sources are likely located in Belfair and the Union River watershed.

Status and Trends: Nineteen stations were evaluated. Eleven were sampled continuously only since late 1996. Thus, the status of these 11 for the current reporting period (January 1999-March 2000) was based on a single statistic. Thirteen stations were **GOOD** (Figure HD9-1). Station 20 (south shore) was **FAIR** for a quarter of the time. Five stations were **BAD**, including four fronting Belfair State Park on the north shore. Stations 18-20 (south shore) had long enough records, and were evaluated for trends. Stations 18 and 19 showed slight but significant improvement. Station 20 showed no change. Individual graphs are shown in Figure HD9-2.

Figure HD9-1. Status and Trends in fecal pollution in Hood Canal Area 9 through March 2000.

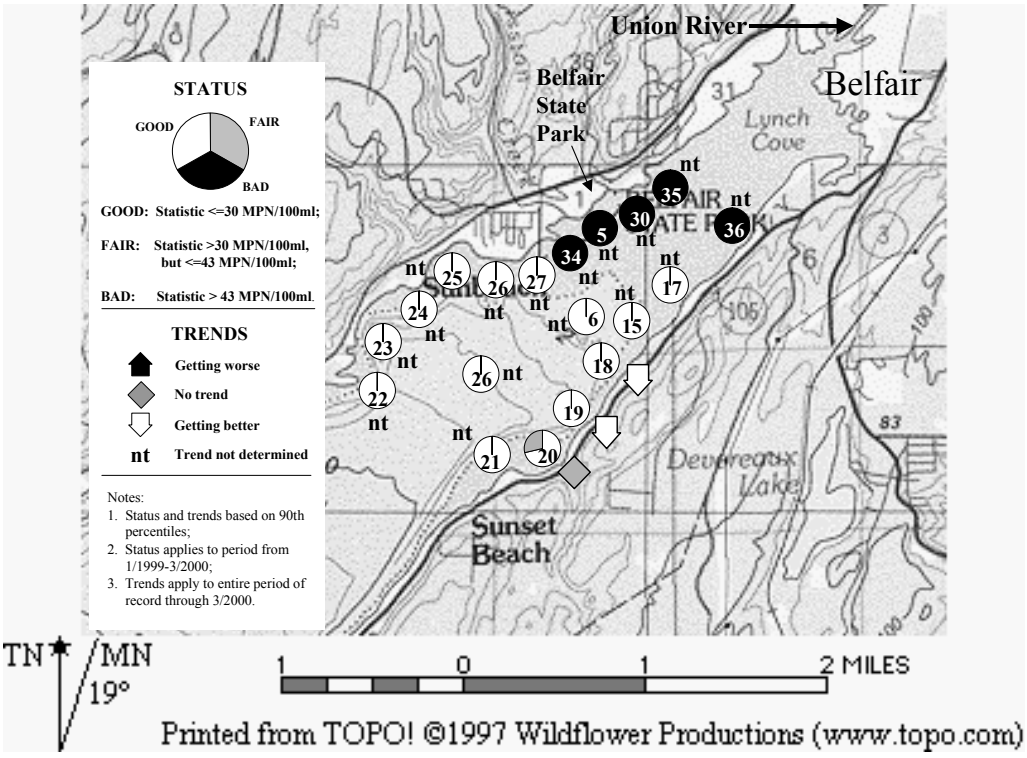
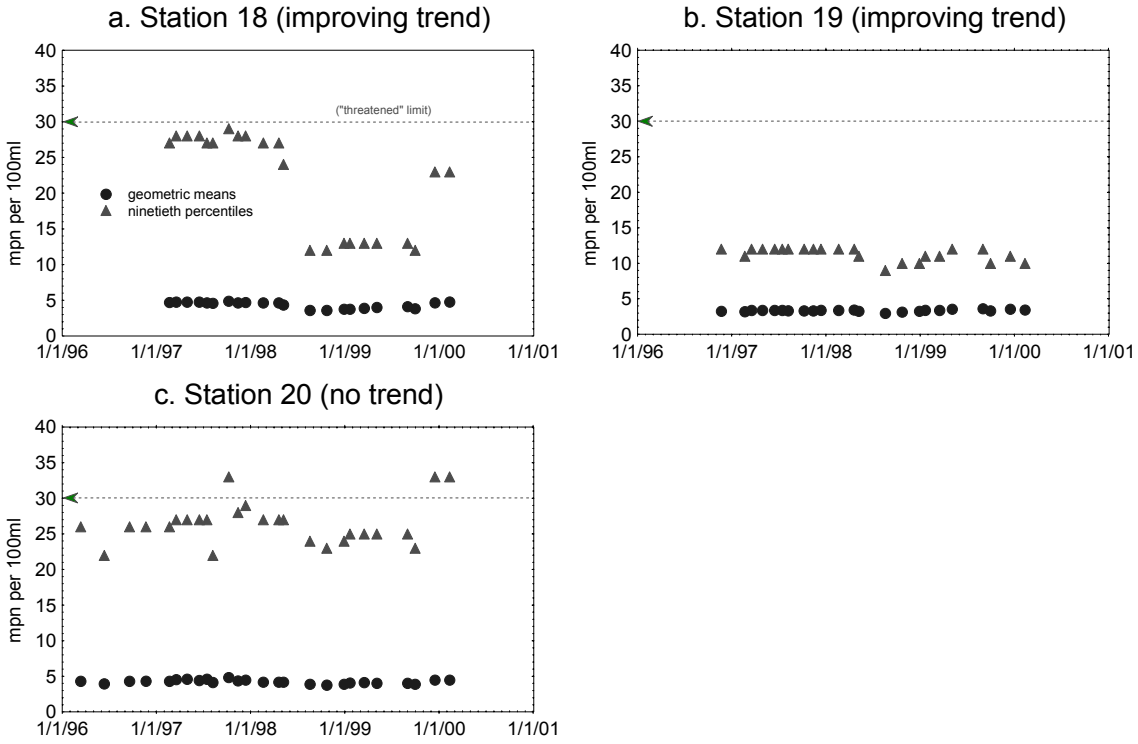


Figure HD9-2. Fecal pollution over time in Hood Canal Area 9.



Kitsap County

LEMOLO (LIBERTY BAY)

Background: Portions of Liberty Bay were **Conditionally Approved** from 1967 through 1990. The remainder was **Prohibited** due to STP discharges from Poulsbo on the east shore and Keyport in the south end. In the late 1970s, the STP discharges were eliminated and harvest was extended into the south end. However, sampling from 1988 through late 1990 indicated that nonpoint fecal pollution was elevated and unpredictable. The **Conditionally Approved** part was downgraded to **Restricted**. A DOH study in 1991 listed major fecal sources: unsewered areas on the west shore; storm runoff from Poulsbo; Dogfish Creek at the north end of Liberty Bay; and four marinas. In mid-1993, DOH restarted sampling at selected sites at the request of the Suquamish Tribe, and a sanitary survey was done. In April 1994, the Lemolo area was upgraded to **Approved**. The area is currently "Inactive".

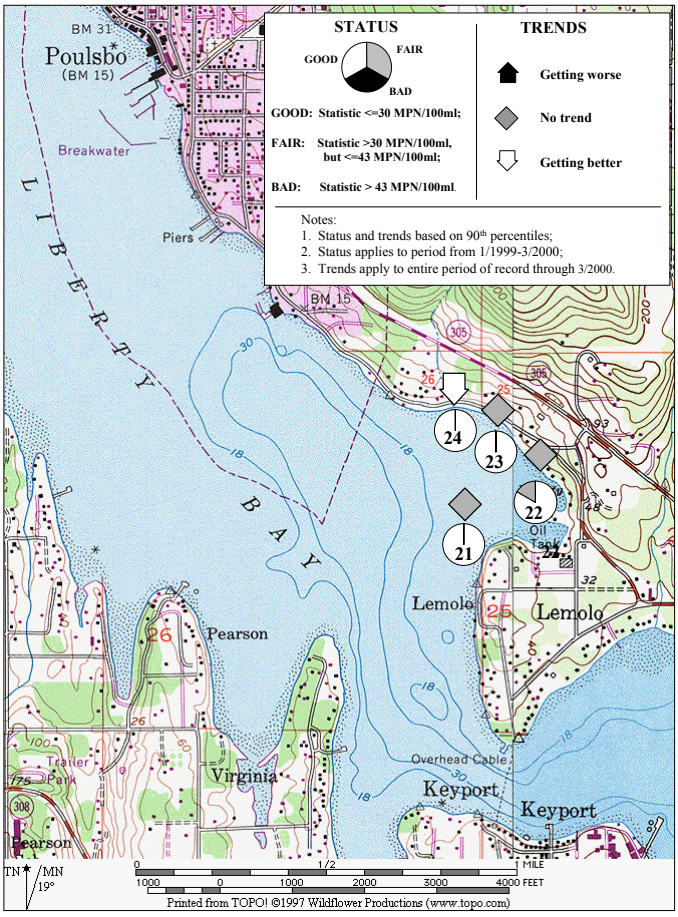
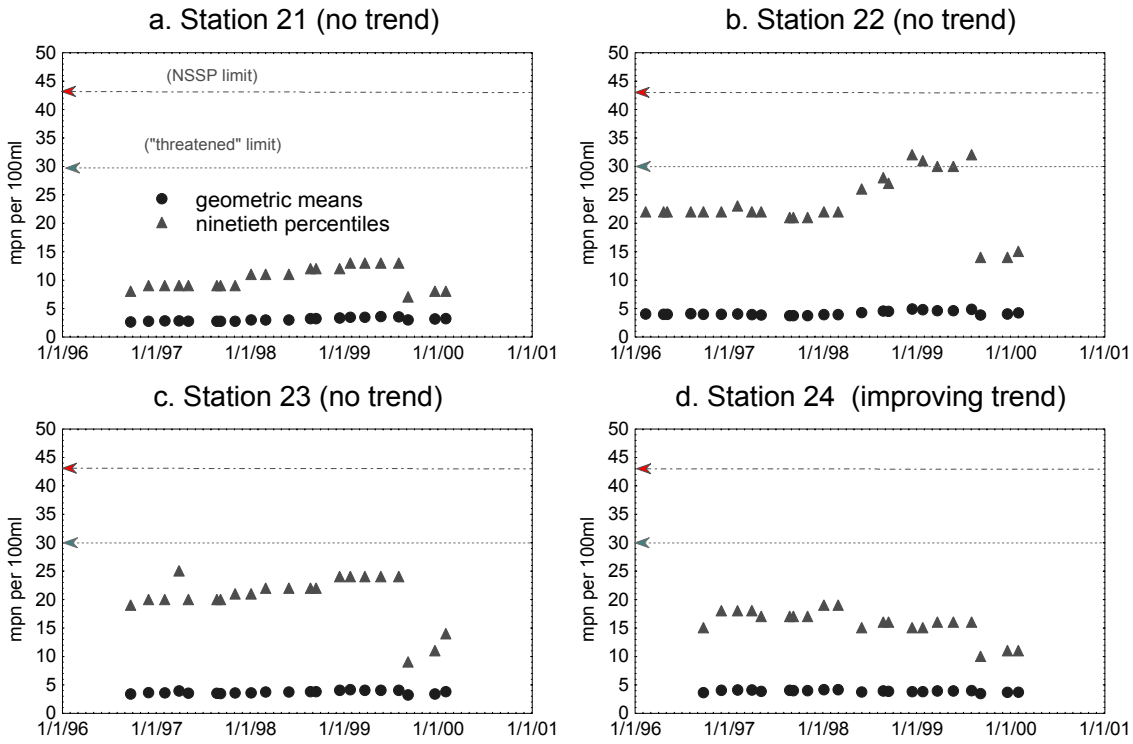


Figure LBR-1. Status and Trends in fecal pollution at Lemolo (Liberty Bay) through March 2000.

Status and Trends: Four stations near Lemolo were evaluated. Three stations were **GOOD** at all times during the current reporting period. Station 22 was **FAIR** part of the time. Trends were analyzed for all stations (see Figure LBR-1). Station 24 showed evidence of improvement. Individual graphs for the four stations are in Figure LBR-2.

Figure LBR-2. Fecal pollution over time at Lemolo (Liberty Bay)



Kitsap County

CHICO BAY (DYES INLET)

Background: Harvest in Dyes Inlet was ended in the 1950s due to nonpoint sources and raw sewage discharges. Although direct sewage discharges were removed, intensive development along the shoreline and combined sewage and stormwater discharges from Bremerton continued. In early 1993, in response to a request from the Suquamish Tribe, DOH began sampling selected sites in Chico Bay and conducted a sanitary survey and hydrographic studies. In December 1993, DOH reclassified Chico Bay as **Restricted** in order to allow relays of shellfish from Chico Bay to cleaner waters. In 1995, Kitsap County conducted a program to find and fix failed on-site sewage systems. A shoreline survey conducted by DOH in January 2001 confirmed the earlier classification.

Status and Trends: Four of seven stations evaluated were **BAD** on all dates during the current reporting period (January 1999-March 2000). These sites are close to shore in an area of minimal water circulation. The status of the other three sites was mixed **GOOD** on most occasions and **FAIR** on the reminder of dates. These sites are located in more open water with greater potential circulation. Trends were not analyzed because of the shortness of the period of record. Therefore no graphs were produced.

Figure DYS-1. Status in fecal pollution at Chico Bay (Dyes Inlet) through March 2000.

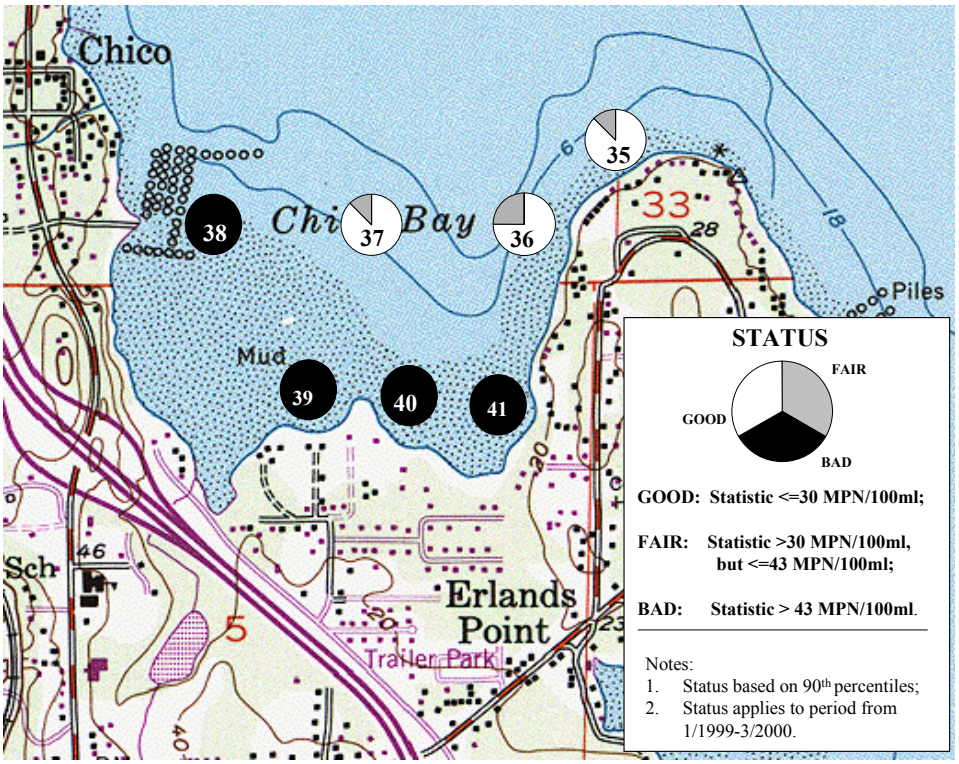


Table of Contents

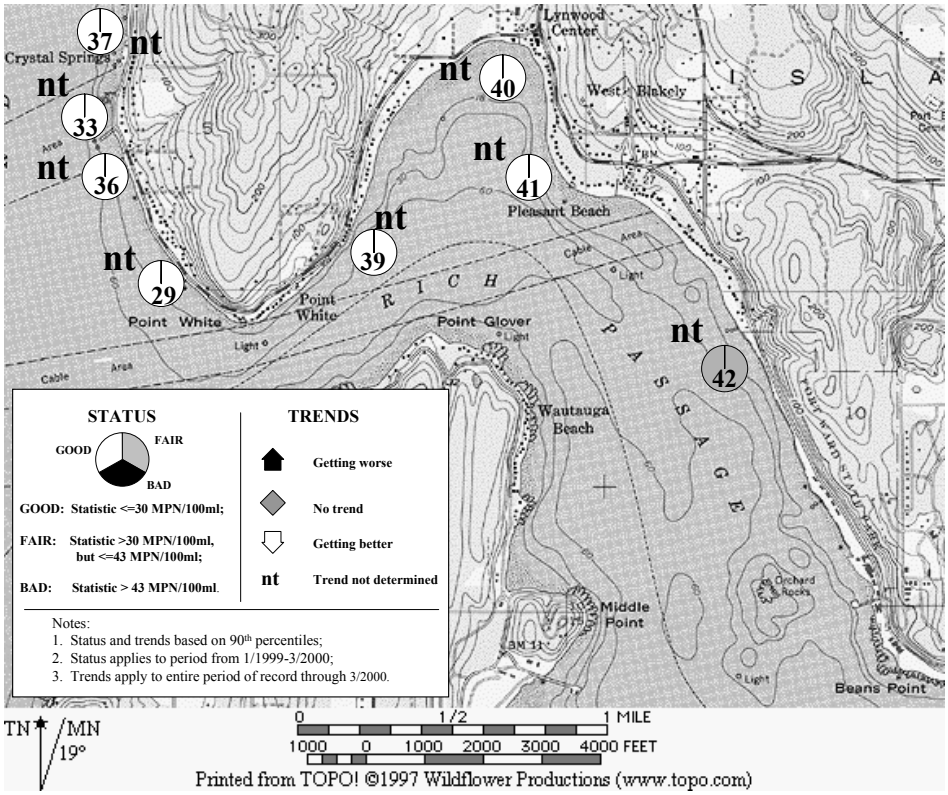
Kitsap County

PORT ORCHARD AND RICH PASSAGE

Background: In response to a request from the Suquamish Tribe, DOH began monitoring the north end of Port Orchard (between Bainbridge Island and the Kitsap Peninsula) in early 1995. A year later, DOH began sampling in the south end. Sampling was extended to Rich Passage in 1999. Shoreline surveys were conducted in 1995, 1997, and 1998. Port Orchard north of Port Bolin was classified **Approved** in 1995. The south end was classified **Approved** in 1998. However, some localized areas are **Prohibited** due to suspect on-site sewage systems along the shore, marinas and STP discharge zones (Fletcher Cove, Crystal Springs, the Brownsville shoreline, and Lynwood Center in Rich Passage). Most of Rich Passage currently remains unclassified.

Status and Trends: Twenty-six stations were evaluated. All but one station was **GOOD** during the current reporting period (January 1999 –March 2000). Station 42 in Rich Passage was **FAIR** (see Figure ORC-1). However, the status must be tentative because the available data were limited. Indeed, the status of each Rich Cove site is based only on a single statistic. By the same token, trends were also not possible due to the limited record. Therefore, graphs were not produced.

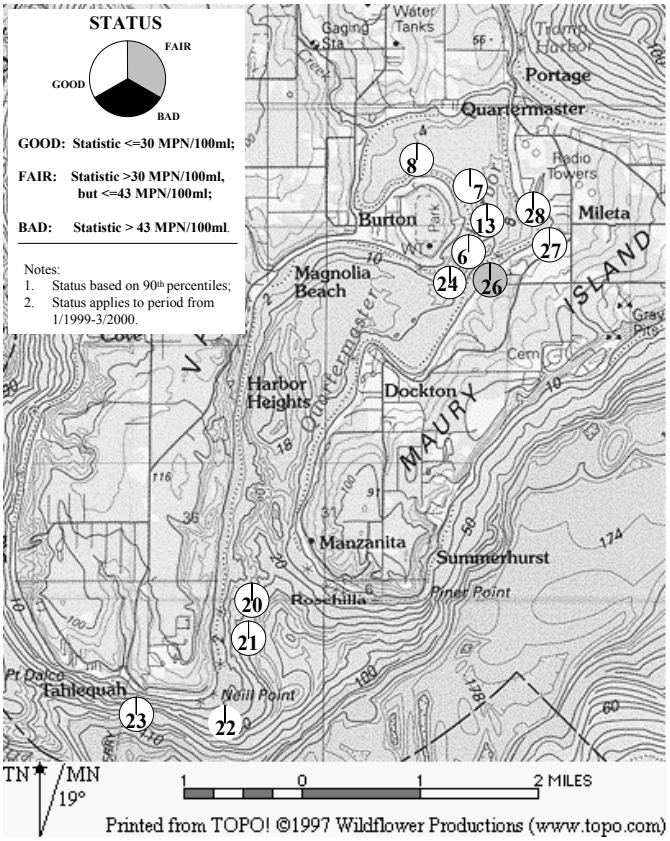
Figure ORC-1. Status in fecal pollution in Rich Passage through March 2000.



King County

QUARTERMASTER HARBOR

Background: Burton Acres Park (Quartermaster Harbor) was classified **Approved** in 1996. At that time, a **Prohibited** zone was placed on 2.5 miles of shoreline south of Burton Acres Park, including the communities of Magnolia Beach and Harbor Heights. In 1998, the Puyallup Tribe petitioned DOH to expand the boundaries of the **Approved** area. In response, DOH conducted a sanitary survey in March 1998, and the **Approved** area near the park was expanded slightly. Areas of Quartermaster Harbor northwest, southwest and southeast of the park have been classified as **Prohibited**.



Status and Trends: Thirteen stations were evaluated. All stations were **GOOD** during the current reporting period (January 1999-March 2000 except Station 26, which was **FAIR** (Figure QMH-1). However, the status of Station 26 is tentative because it is based only on a single statistic. Trends were not warranted due to the limited length of the record. Therefore, graphs were not produced.

Figure QMH-1. Status and Trends in fecal pollution in Quartermaster Harbor through March 2000.

Thurston and Pierce counties

NISQUALLY REACH

Background. In 1992, part of Hogum Bay near McAlister Creek was downgraded to **Conditionally Approved**. Local agencies began remedial programs. Some livestock farms in the floodplain implemented farm plans. Thurston County found 32 shoreside failed on-site sewage systems out of 123 inspected. All were repaired. Despite these efforts, fecal pollution increased. In response, DOH downgraded the east end of the **Conditionally Approved** zone to **Restricted** and upgraded the west end to **Approved** in October 2000.

Status and Trends: Thirteen of 28 stations were **GOOD** during the current reporting period (January 1999-March 2000). Four stations were **BAD** on all dates. Two are near the mouth of the Nisqually River. Two other **BAD** sites are near the mouth of McAlister Creek and Luhr Beach to the west. Thirteen **GOOD** stations were northwest of Hogum Bay. Figure NSQ-1 suggests a gradient of effect outward from the rivers. Nearly half of the stations showed a worsening trend over the period of record. The worsening stations were generally located closest to the two rivers. Figure NSQ-2 has graphs of selected stations. Stations 16 and 26 (near McAlister Creek) showed the highest statistics.

Figure NSQ-1. Status and trends of fecal coliform pollution in Nisqually Reach through March 2000.

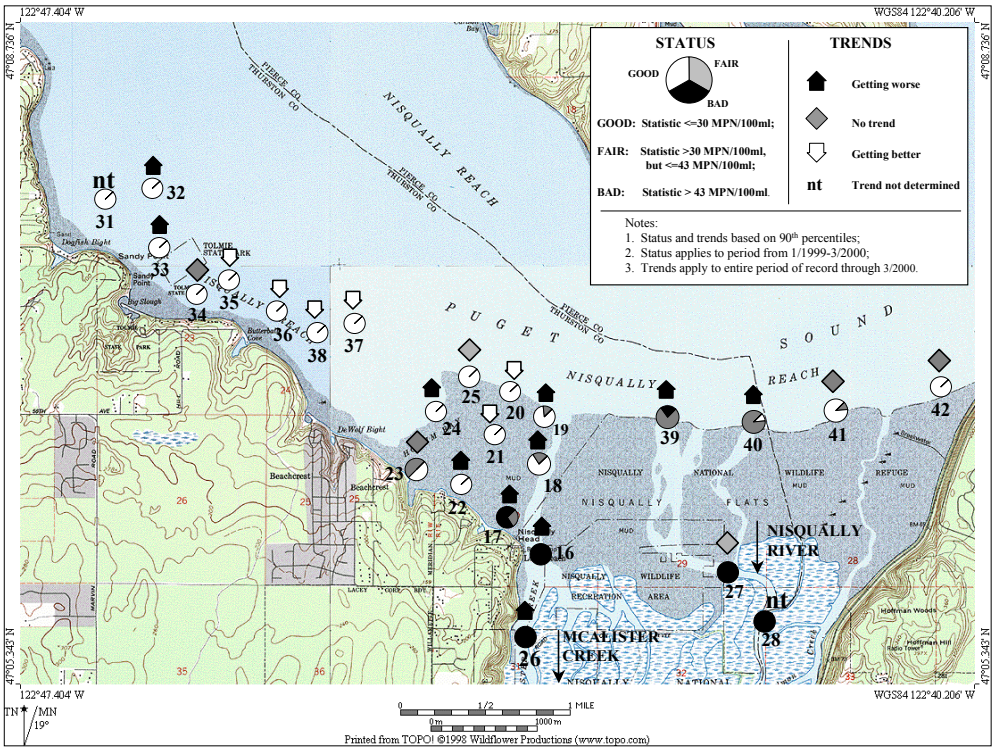


Table of Contents

Figure NSQ-2. Fecal pollution over time at stations in Nisqually Reach.

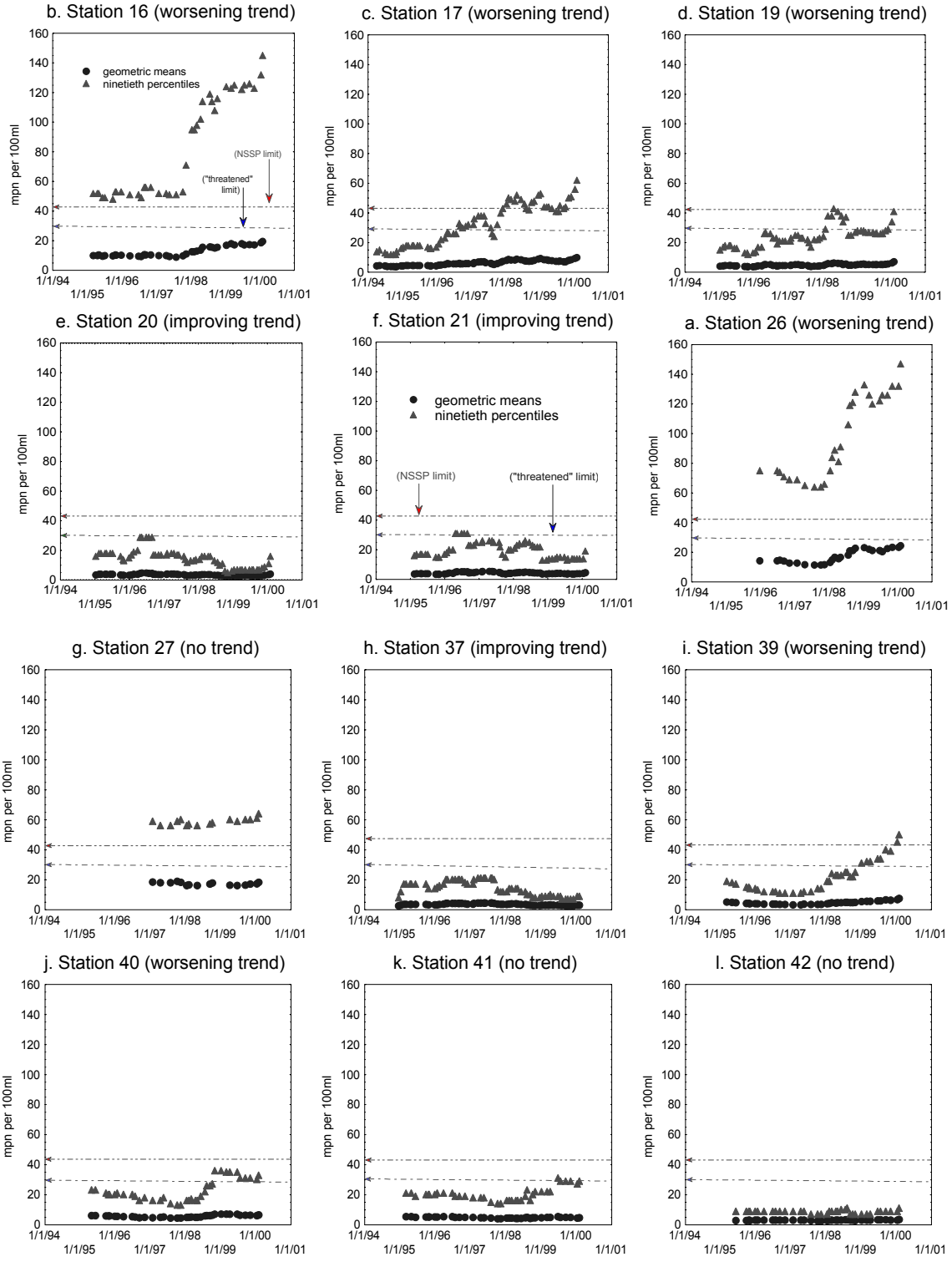
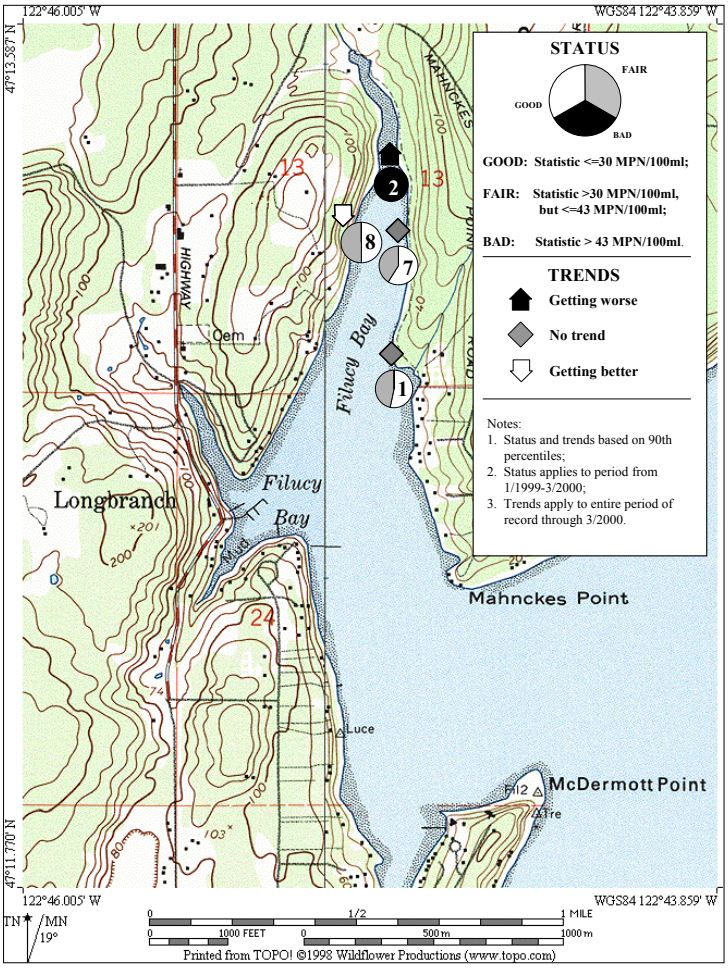


Table of Contents

Pierce County

FILUCY BAY

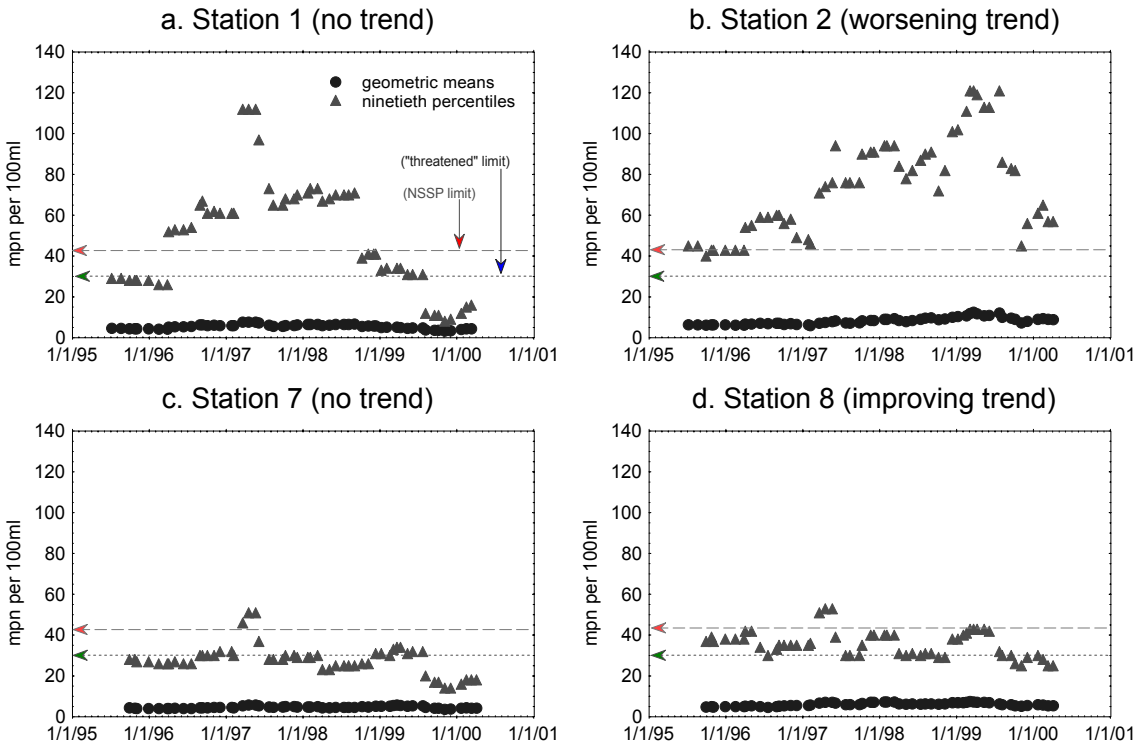
Background. Prior to 1994, all of Filucy Bay was classified as **Conditionally Approved** due to seasonally high occupancy of the Longbranch Marina. In that year, a permanent closure was placed around the marina and a rainfall-based **Conditionally Approved** classification was placed on the remainder of Filucy Bay. DOH performed shoreline surveys in 1994 and 1999. Although no failed systems were found, soil conditions were found to be generally unsuitable for adequate on-site system function. Also, there were nine sites with pastured livestock. Roughly 25 percent of the animals had direct access to water. Due to continued fecal coliform contamination, DOH began another downgrade process in early 2001.



Status and Trends: Station 2 was **BAD** on all occasions during the recent reporting period (January 1999-March 2000). Fecal pollution at Station 2 is worsening. The other three stations were mixed **GOOD** and **FAIR** (Figure FLC-1). Station 8 is improving. The other two sites haven't changed significantly. Figure FLC-2 has a graph for each station. Station 1 appears to have improved since late 1998, and the graphs suggest a recent improving trend at all four stations during the past year. However, the time frame for this trend is too short for certainty.

Figure FLC-1. Status and trends in fecal pollution at Filucy Bay through March 2000.

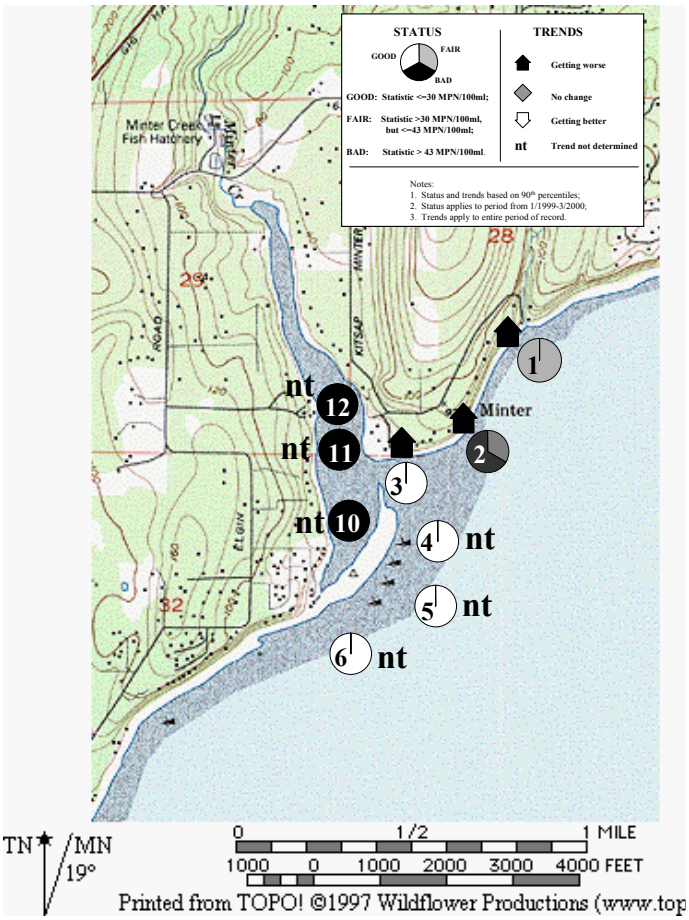
Figure FLC-2. Fecal pollution over time at stations in Filucy Bay.



Kitsap and Pierce counties

MINTER BAY (HENDERSON BAY)

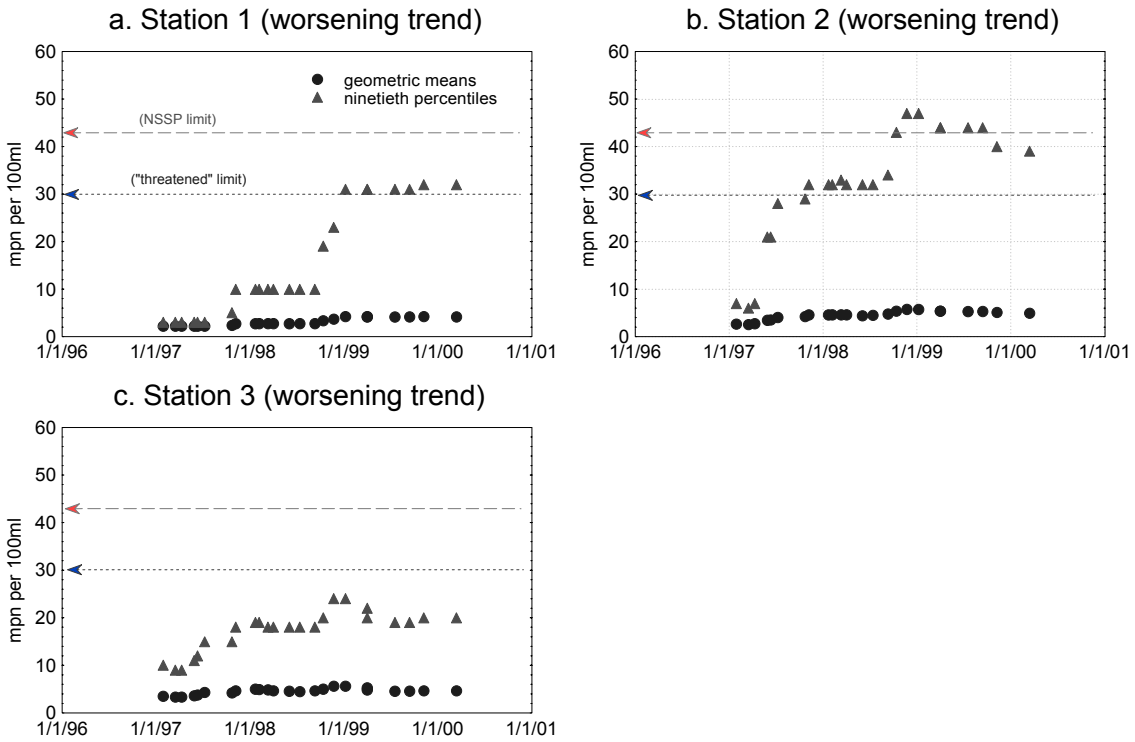
Background. Sampling of most individual harvest sites in Henderson Bay has been done since the early to mid 1990s. But Minter Bay on the northwest shore had a long prior history. In 1982, Minter Bay was downgraded from **Approved** to **Prohibited**. Waters outside Minter Bay continued to be **Approved**. Water quality studies and nonpoint remedial action in the Minter watershed were taken through the early '90s. No measurable improvement resulted. Data analysis done in 1994 by DOH suggests that shoreline sources are likely responsible for fecal pollution in Minter Bay. DOH stopped monitoring Minter Bay in the early '90s, but sampling was resumed in early 1998.



Status and Trends: Nine of 13 stations scattered throughout Henderson Bay were **GOOD** during the current reporting period (January 1999-March 2000), including four sites outside Minter Bay (Figure HNB-1). Two others outside Minter Bay had mixed status. Three stations within Minter Bay were **BAD**. (tentative conclusion based on a single statistic). Only the three stations outside Minter Bay had records long enough or statistics high enough to warrant trends analysis. All three stations show increasing pollution.

Figure HNB-1. Status and trends of fecal pollution in Minter Bay (in Henderson Bay) through March 2000

Figure HNB-2. Fecal pollution over time at stations in Minter Bay (in Henderson Bay).



Kitsap and Pierce counties

BURLEY LAGOON

Background: Shellfish beds in Burley Lagoon were downgraded in 1981 from **Approved** to **Restricted** due to nonpoint fecal sources from the watershed. Health agencies and conservation districts have periodically conducted remedial programs. Repair of several large on-site sewage systems and connection of the Peninsula High School and several businesses in Purdy led to the upgrade of the shellfish beds from **Restricted** to **Conditionally Approved** in 1993. But by early 1997, water quality began to decline. In early 1999, Burley Lagoon was once again classified **Restricted**. The downgrade resulted in renewed remedial action.

Status and Trends: Four of 12 stations were **GOOD** on all occasions during the current reporting period (January 1999-March 2000). These stations lie along the central axis of Burley Lagoon and are a maximum distance away from shoreline influences. One station along the west shore (Station 10) was **BAD** on all dates. The status of the remaining 8 stations was mixed. There appears to be no apparent spatial distribution of impact (Figure BRL-1). Eight of 12 stations have worsened over the entire period of record. One station improved and three others stayed the same. Figure BRL-2 shows graphs of selected stations.

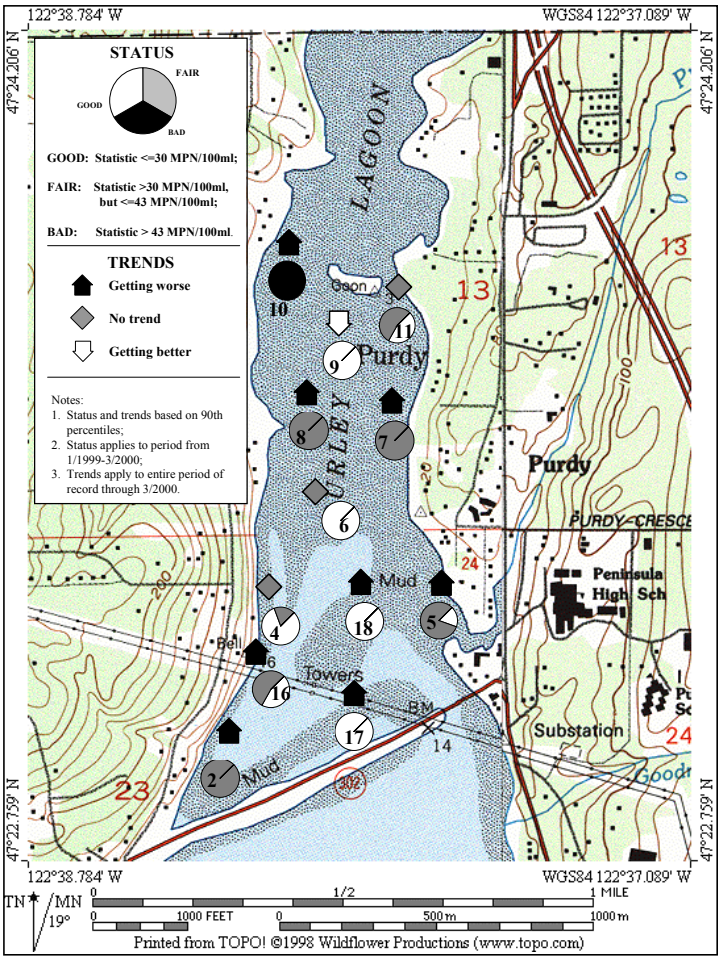


Figure BRL-1. Status and trends of fecal pollution in Burley Lagoon through March 2000.

Table of Contents

Figure BRL-2. Fecal pollution over time at stations in Burley Lagoon.

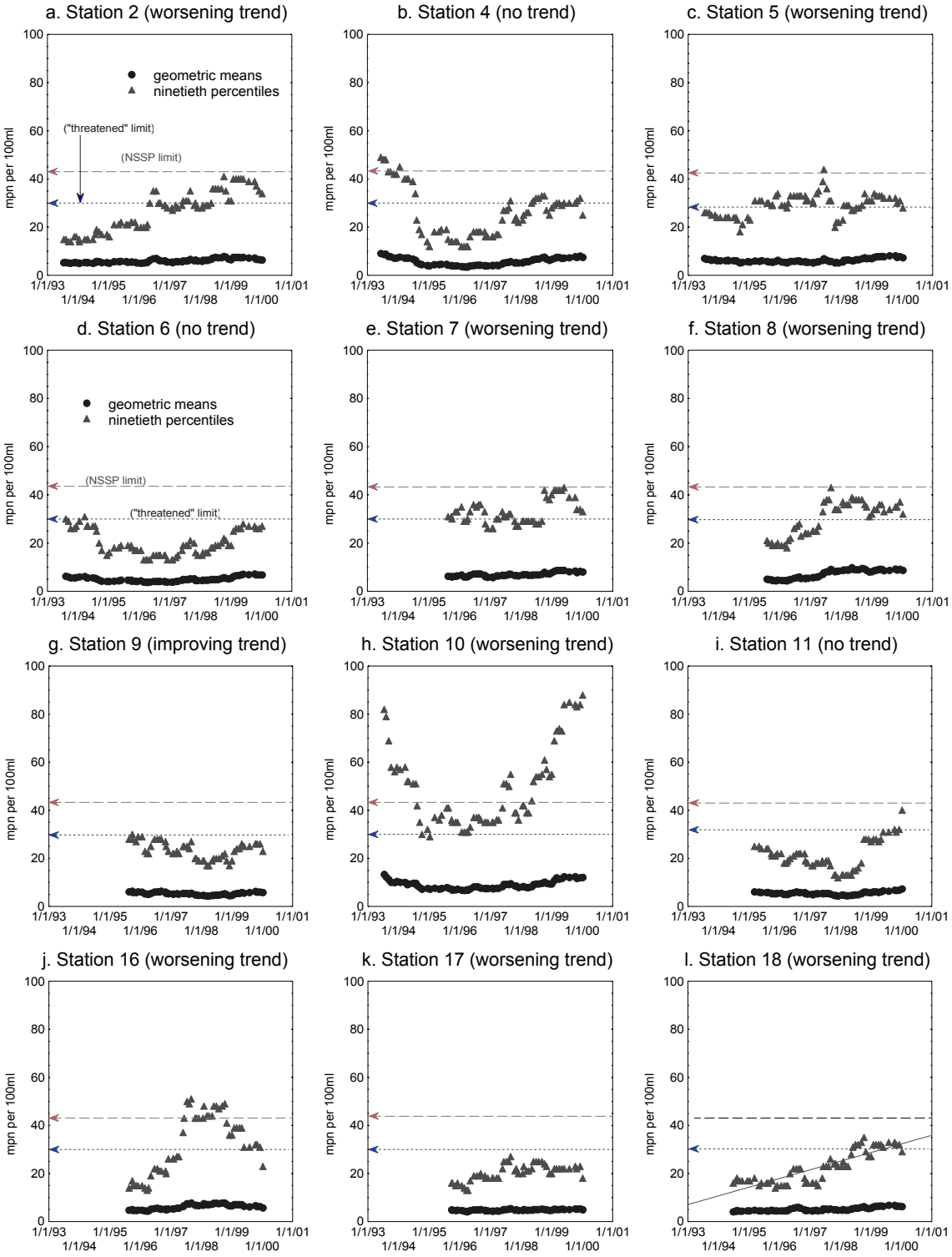
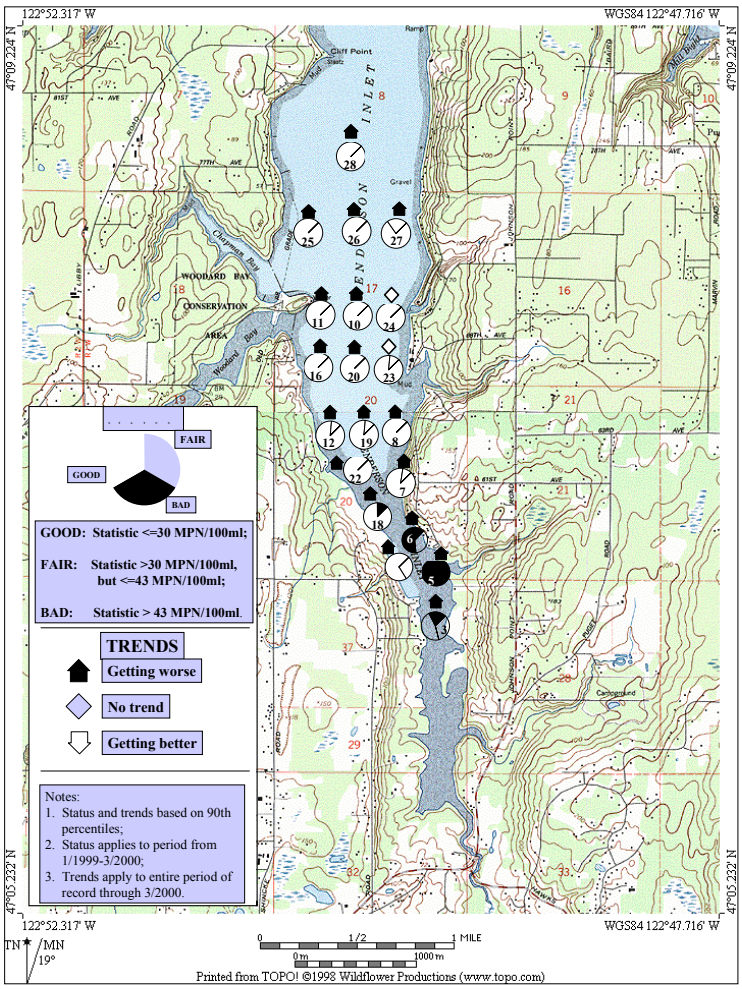


Table of Contents

Thurston County

HENDERSON INLET

Background: In 1985, DOH downgraded the south end of Henderson Inlet to **Prohibited** and established a **Conditionally Approved** zone just to the north. Early studies indicated the primary sources of fecal pollution were failed on-site systems and inadequate pasture management from uplands and the marine shoreline. Despite control measures (voluntary implementation of farm management practices, search for failed on-site systems, updated standards for on-site sewage standards, land-use density limits, stormwater management, etc.), contamination has intensified. In October 2000, DOH expanded the **Prohibited** area northward into the Inlet.

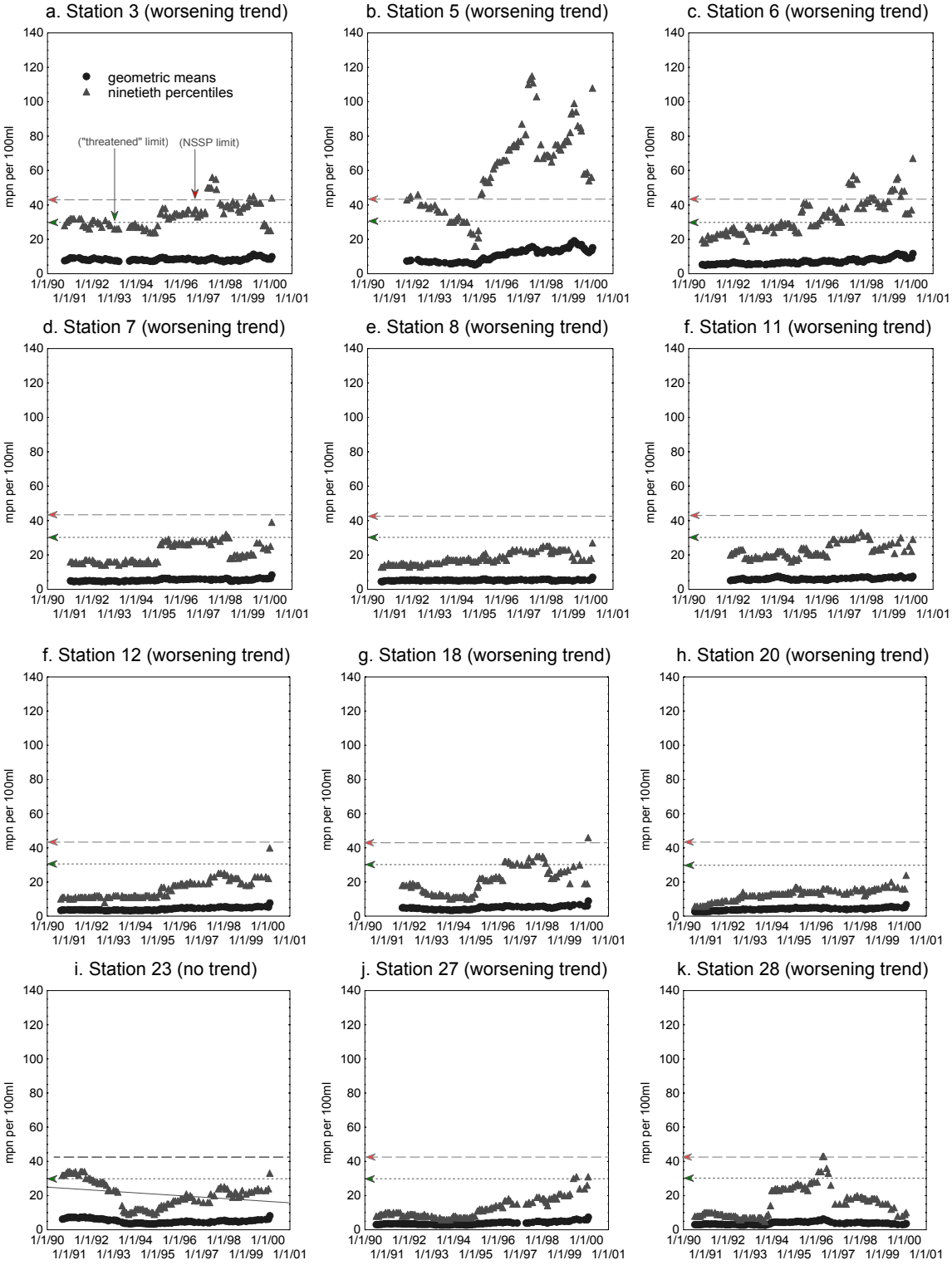


Status and Trends:

Ten of 20 stations examined were **GOOD** on all occasions during the current period (January 1999-March 2000). Station 5 at the south end was **BAD** all the time. The remaining 9 stations were mixed **GOOD**, **FAIR**, and **BAD** (Figure HNL-1). Trend analysis indicated that 18 of 20 stations had increased pollution over the entire period of record. Two stations showed no change. Figure HNL-2 shows individual plots for selected stations.

Figure HNL-1. Status and trends of fecal pollution in Henderson Inlet through March 2000.

Figure HNL-2. Fecal pollution over time in Henderson Inlet.



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Thurston County

ELD INLET

Background: Six hundred ninety acres of shellfish growing area in the south end of Eld Inlet were downgraded to **Conditionally Approved** in 1983. Major sources of fecal pollution were failing on-site sewage systems and poor livestock keeping. Since 1993, Thurston County has adopted a nonpoint pollution control ordinance, set maximum density limits (1 unit per 5 acres) in most rural areas, and revised its on-site sewage code. In the mid-1990s, Thurston County Health District staff carried out focused and technically rigorous inspections of on-site sewage systems along the marine shoreline. Community participation ranged from 72 to 96 percent. Sixteen percent of the 564 systems were failing. All have been repaired. DOH upgraded 450 acres of **Conditionally Approved** area to **Approved** in 1998.

Status and Trends: Twenty of 22 stations in Eld Inlet were **GOOD** for all dates within the current reporting period (January 1999-March 2000). Stations 6 and 7 at the southern end of Eld Inlet were **FAIR** on some dates (Figure ELD-1). The slightly elevated pollution likely came from nearby creeks coupled with minimal tidal exchange at that point in the Inlet. Fecal coliform pollution decreased at 13 stations where trends were determined. Three stations in the southern end were unchanged. Six remaining stations were too low to warrant trends analysis. The greatest improvement occurred at several stations close to shoreline communities where many failed on-site sewage systems were repaired. Graphs of selected stations are in Figure ELD-2.

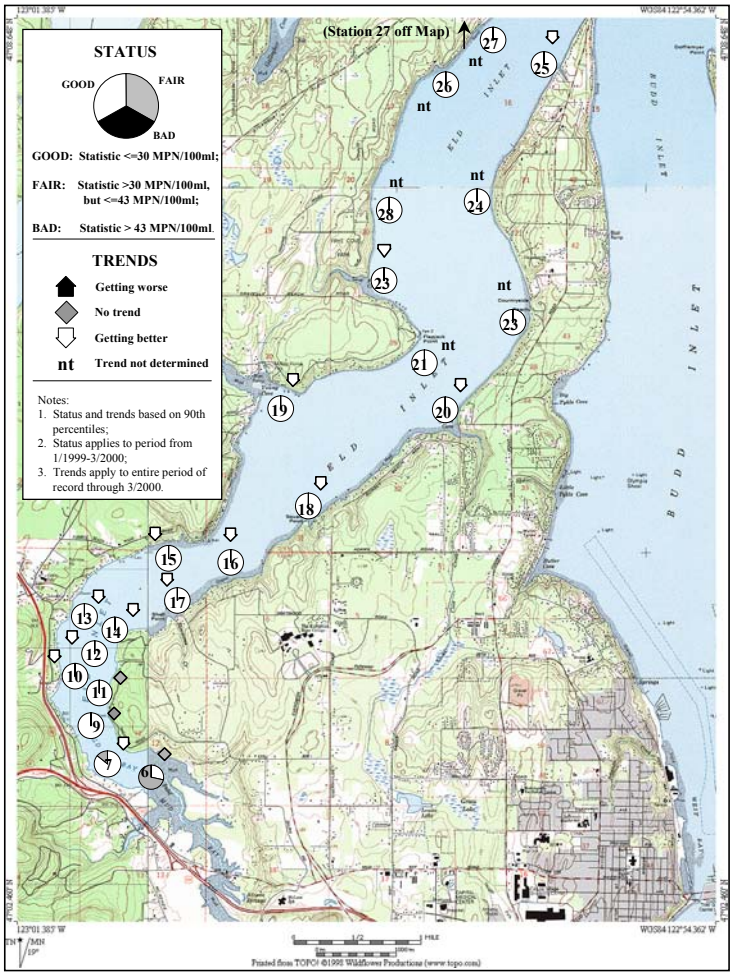
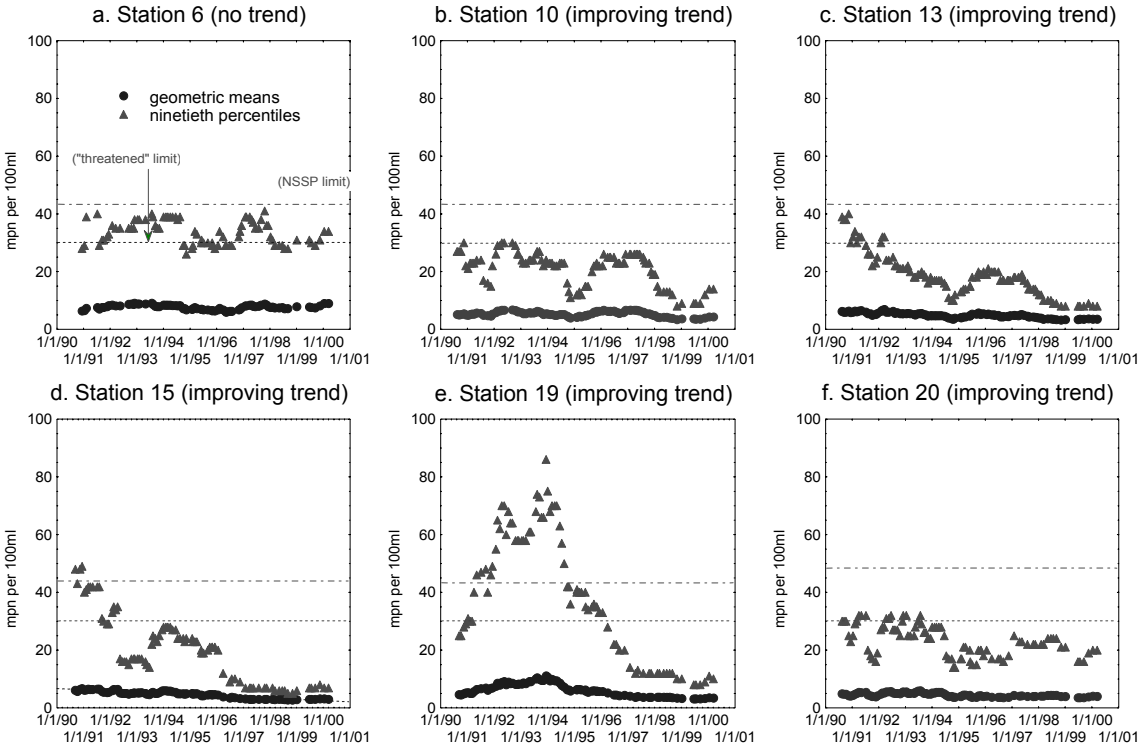


Figure ELD-1. Status and trends of fecal pollution in Eld Inlet through March 2000.

Figure ELD-2. Fecal pollution over time at selected stations in Eld Inlet.



Mason County

OAKLAND BAY

Background: The southwestern end of Oakland Bay is permanently closed to shellfish harvest due to the discharge of the Shelton Sewage Treatment Plant (STP). Another 1,380 acres of shellfish ground were downgraded to **Restricted** in 1987. Infiltration and inflow into Shelton's aging sewer collection system caused overflowing sewage to mix with stormwater runoff during storms. In 1989, following initial remedial action, Oakland Bay was reclassified **Conditionally Approved**. In recent years, the city has renovated over half of the sewer lines and installed collection lines in previously unsewered areas.

Status and Trends: Ten of 13 stations were classified as **GOOD** on all sampling dates within the current reporting period (January 1999-March 2000). Station 3 near the Shelton STP outfall was **FAIR** on half of all sampling dates. Station 7 (near the shoreline community of Bayshore) had one **FAIR** date out of 15 (Figure OKL-1). Overall trends have improved at ten stations since 1990 (Figure OKL-1). However, stations 7, 11, and 16 may have worsened since 1996 (Figure OKL-2e, h, and j).

Figure OKL-1. Status and trends of fecal pollution in Oakland Bay through March 2000.

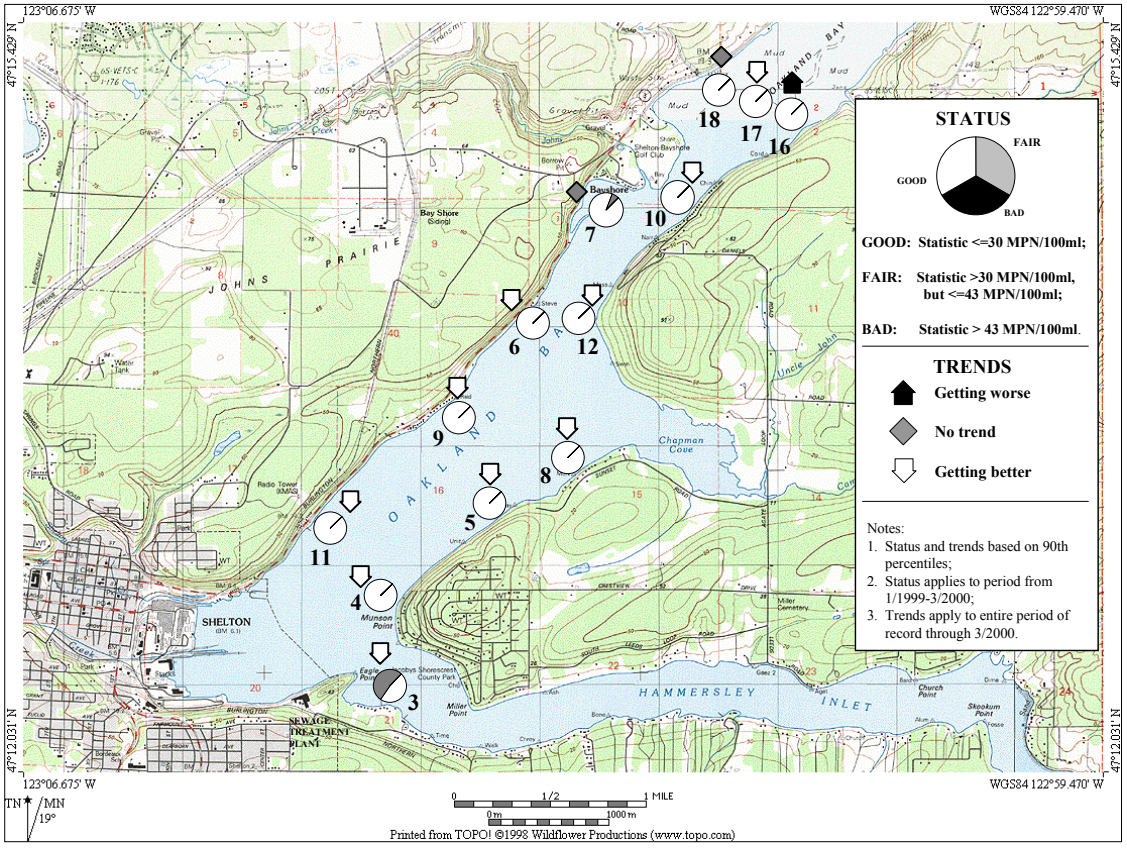
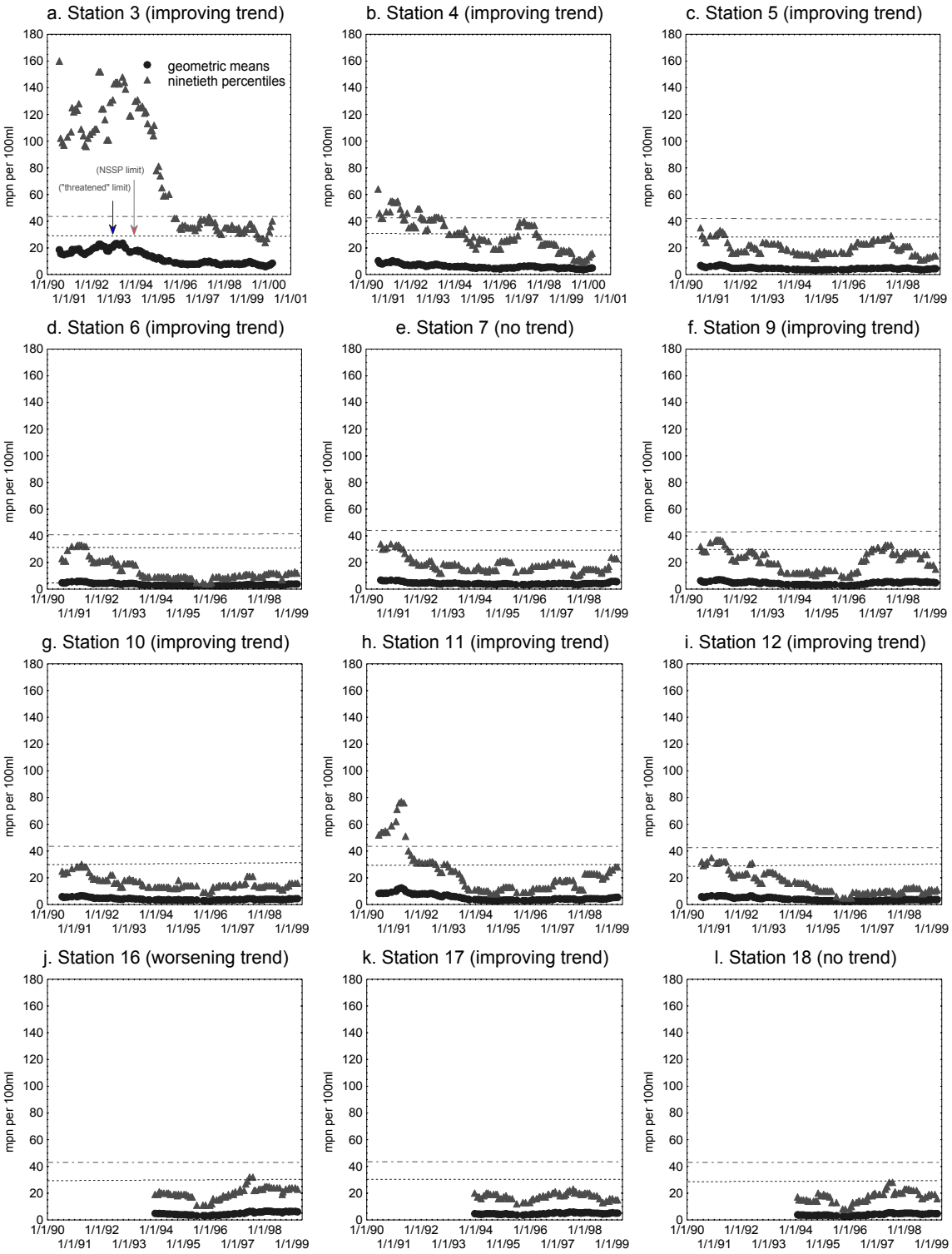


Table of Contents

Figure OKL-2. Fecal pollution over time at selected stations in Oakland Bay.



Mason County

NORTH BAY

Background: In 1991, 1,260 acres of shellfish bed were downgraded to **Prohibited**. Just over a third of on-site sewage systems in Allyn were failing. As a result, DOH declared a severe public health hazard and a large shellfish grower began legal action against individual operators of failed individual sewage systems. From May 1991 through October 1992, most of the failed systems were repaired. Later that year, 450 acres of **Prohibited** area was upgraded to **Conditionally Approved**. Subsequently, 710 **Prohibited** acres were changed to **Conditionally Approved** and 100 **Prohibited** acres fronting Allyn became **Restricted**. Planning began and funding was sought for a sewage collection and treatment system. The **Restricted** acres were reclassified Inactive in March 1996 after commercial harvest was suspended. Soon after, Washington State purchased part of the northern end of the bay from a private shellfish interest.

Status and Trends: Eleven of 14 sites were **GOOD** at all times during the current reporting period (January 1999-March 2000). Three stations along the western shore near Allyn sometimes scored **FAIR** (figure NRB-1). Trends were determined at 13 of 14 stations (Station 27 excluded) over the period of record (since 1993-1994). Seven stations have improved. Two others remained unchanged. Four have worsened, including Station 5 near Allyn. Figure NRB-2a suggests that although the long-term trend at Station 5 has been upward, fecal pollution may have dropped recently. However, the trend is likely not significant due to the limited record. The highly significant improvement at Station 17 (figure NRB-2d) is noteworthy. Overall, fecal pollution appears to have subsided at four of five sites on the west shore. Two of seven stations on the east side show a degrading trend (e.g., Station 9, see Figure NRB-2c).

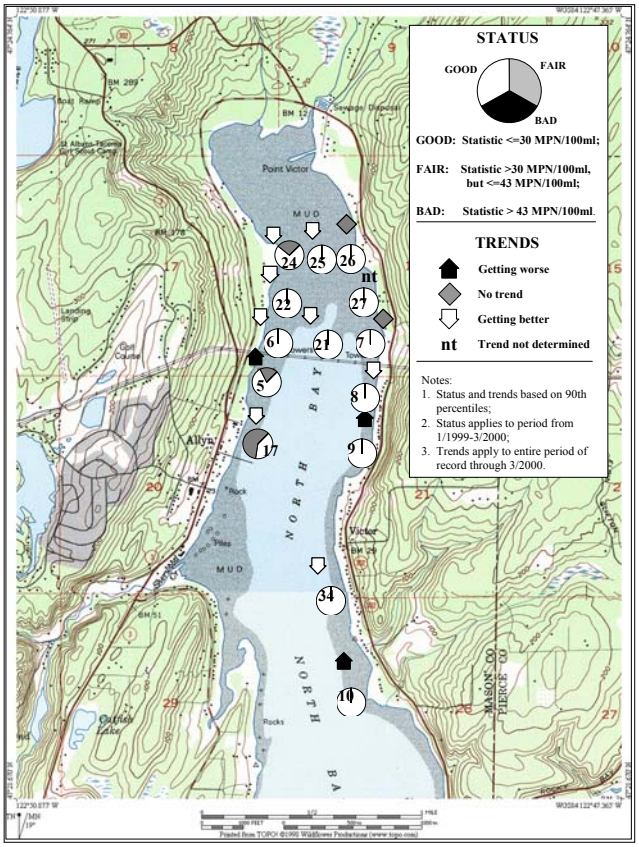
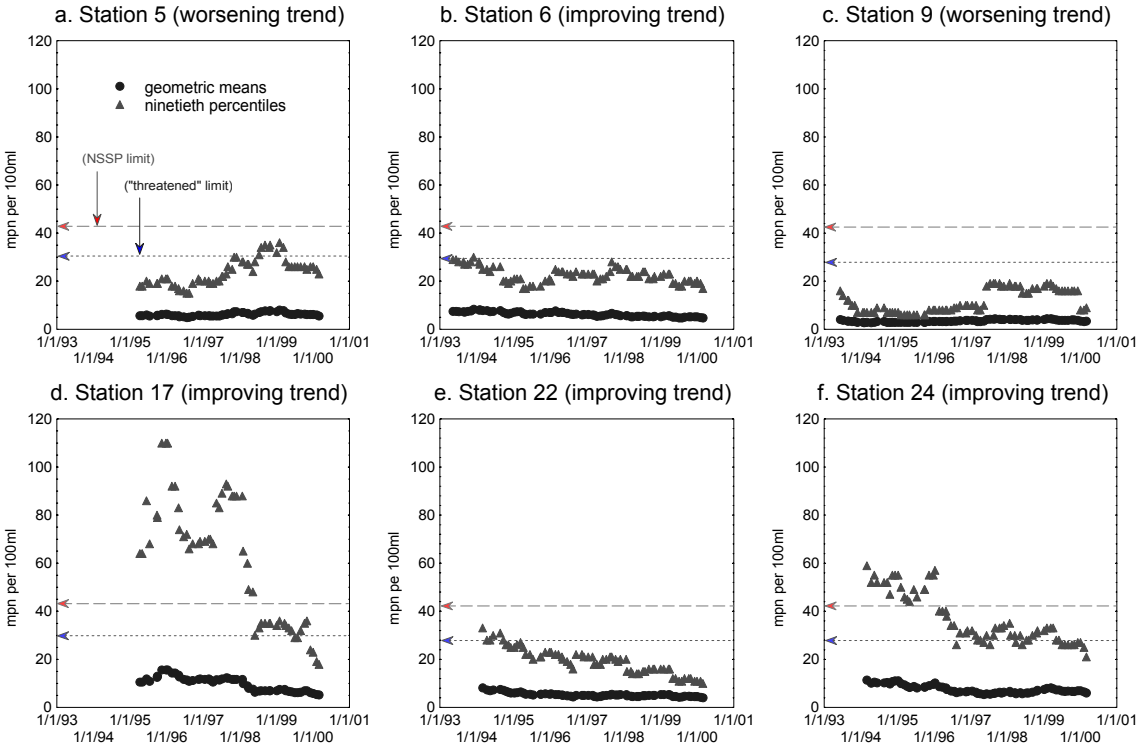


Figure NRB-1. Status and trends of fecal pollution in North Bay through March 2000.

Figure NRB-2. Fecal pollution over time at stations in North Bay.



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APPENDIX A:

DATA ANALYSIS FOR CLASSIFICATION OF GROWING AREAS

Until recently, the Washington State Department of Health was required to use U.S. FDA (1995) to classify shellfish growing areas. U.S. FDA (1997) has now superseded U.S. FDA (1995). Both documents mandate a "systematic random sampling" (SRS) strategy. The procedure requires a minimum of 30 samples be collected prior to determining classification. After the required minimum number of results are obtained, two "SRS" statistics (geometric mean and 90th percentile) are calculated for each sampling station, and compared to the following criteria:

- the geometric mean of the fecal coliform data shall not exceed 14 MPN per 100 ml;
- the estimated 90th percentile of the fecal coliform data shall not exceed 43 MPN per 100 ml.

Both SRS criteria must be met in order to be classified **Approved** (i.e., no harvest restrictions).

If a station fails at least one of the SRS criteria, it cannot be classified as **Approved**. However, if it appears that failure is linked to rainfall, the data can be reexamined to determine the threshold rainfall conditions under which water quality may be acceptable for harvest (i.e. criteria for **Conditionally Approved** classification). "Adverse Pollution Conditions " (APC) criteria are applied in this case (U.S. FDA 1995). A minimum of 15 results is required to apply APC criteria:

- the geometric mean of the fecal coliform data shall not exceed 14 MPN per 100 ml;
- No more than ten percent of values in the data set shall exceed 43 MPN per 100 ml.

[Note: the APC criteria are identical to the fecal coliform criteria in the Surface Water Quality Standards of the State of Washington (Chapter 173-201A WAC) for Class A and AA marine waters.]

To evaluate the APC criteria, the analyst follows the following procedure:

1. The analyst sorts the fecal coliform data according corresponding one-day rainfall.
2. The data are then grouped according to quarter-inch increments of rainfall (2.00"-1.75"; 1.75"-1.5"; 1.25"-1.00", etc.).
3. The analyst then removes from the full data set those fecal coliform values associated with the highest quarter-inch increment of one-day rainfall.
4. The remaining data are used to recalculate the two APC statistics.

The recalculated statistics are compared once again to the APC criteria. If one or both APC statistics still do not meet the criteria:

1. The analyst removes from the remaining data set the fecal coliform value associated with the group representing the next highest increment of daily rainfall.
2. The statistics are recalculated with the remaining data.

3. These new statistics are again compared with APC criteria.

The analyst repeats the process until both criteria are met. The station is then classified as **Conditionally Approved**. The highest one-day rainfall increment remaining in the data set constitutes the upper **Conditionally Approved** limit for rainfall. Rainfall in excess of the limit results in a temporary closure of the growing area until suitable conditions return.

If the APC criteria cannot be met at a one-day rainfall total of 0.5", the station is classified as **Prohibited** (i.e., no harvest under any conditions) or **Restricted** (i.e., shellfish must be relayed to an **Approved** area for depuration). If the station doesn't comply with fewer than 15 values remaining, the station cannot be classified.

Following initial classification of a growing area, compliance is assured through perpetual monitoring. The sampling frequency depends on the area's classification: **Approved** areas are sampled six times a year; **Conditionally Approved** areas are sampled monthly.

APPENDIX B. Summary of statistical tests for trends at selected stations through March 2000. Trend for each station extends from the earliest date ninetieth percentiles were available.

Notes:
1. Null hypotheses was accepted (I.e. no trend) if p-level was greater than 0.05.
2. Null hypothesis rejected only if both tests agree.
3. Trends based on the following criteria:
   a. Ninetieth percentiles were available for a minimum of three years.
   b. At least one ninetieth percentile greater than 10 MPN per 100ml.

MARINE	GROWING	stn	earliest date		Spearman		Kendall			
BODY	AREA	n.	stats available	n	Rho	p-level	Tau	p-level	conclusion	trend
Strait	Drayton	3	Aug-95	39	0.528	0.000	0.410	0.000	significant	increasing
of Georgia	Harbor	4	Aug-95	42	0.091	0.566	0.044	0.683	not significant	same
		5	Aug-95	40	0.094	0.566	0.082	0.460	not significant	same
		6	Aug-95	40	0.421	0.007	0.317	0.004	significant	increasing
		8	Aug-95	35	0.818	0.000	0.666	0.000	significant	increasing
		12	Aug-95	39	0.604	0.033	0.425	0.000	significant	increasing
North	Portage	9	Dec-97	17	0.636	0.006	0.448	0.012	significant	increasing
Puget	Bay	10	Mar-97	35	0.817	0.000	0.675	0.000	significant	increasing
Sound		11	Mar-97	37	0.054	0.752	0.029	0.800	not significant	same
		12	Mar-97	37	0.756	0.989	0.596	0.000	significant	increasing
		13	Mar-97	34	0.658	0.000	0.527	0.000	significant	increasing
		14	Mar-97	33	-0.781	0.000	-0.562	0.000	significant	decreasing
		15	Mar-97	33	-0.480	0.005	-0.336	0.006	significant	decreasing
		16	Feb-97	36	0.051	0.659	0.106	0.536	not significant	same
Bellingham	Samish	1	Sep-94	47	0.798	0.000	0.667	0.000	significant	increasing
Bay	Bay	2	Oct-94	45	0.275	0.067	0.167	0.106	not significant	same
		3	Oct-94	45	-0.150	0.325	-0.041	0.693	not significant	same
		4	Oct-94	45	0.722	0.000	0.519	0.000	significant	increasing
		5	Oct-94	45	-0.124	0.416	-0.028	0.787	not significant	same
		6	Oct-94	44	-0.916	0.000	-0.775	0.000	significant	decreasing
		7	Oct-94	45	-0.760	0.000	-0.591	0.000	significant	decreasing
	.	8	Nov-94	44	-0.933	0.000	-0.783	0.000	significant	decreasing
		9	Oct-94	45	-0.883	0.000	-0.727	0.000	significant	decreasing
		10	Oct-94	56	0.872	0.000	0.681	0.000	significant	increasing
		11	Oct-94	56	-0.180	0.184	-0.093	0.310	not significant	same
		12	Nov-94	56	0.135	0.322	0.116	0.206	not significant	same
		13	Dec-94	49	0.255	0.077	0.187	0.059	not significant	same
		15	Mar-95	40	0.629	0.000	0.415	0.000	significant	increasing
		17	Oct-96	34	-0.390	0.022	-0.258	0.030	significant	decreasing
		18	Dec-96	32	-0.669	0.000	-0.499	0.000	significant	decreasing
		19	Dec-96	32	0.657	0.000	0.462	0.000	significant	increasing
		20	Nov-96	33	0.630	0.000	0.439	0.000	significant	increasing
		21	Nov-96	33	0.404	0.020	0.172	0.160	not significant	same
		22	Dec-96	20	-0.696	0.001	-0.525	0.001	significant	decreasing

MARINE BODY	GROWING AREA	stn n.	earliest date stats available	n	Spearman Rho	p-level	Kendall Tau	p-level	conclusion	trend
Whidbey Basin	South Skagit Bay	1	Feb-95	52	-0.727	0.000	-0.492	0.000	significant	decreasing
		2	Jan-95	53	0.686	0.000	0.404	0.000	significant	increasing
		3	Jan-95	53	0.864	0.000	0.704	0.000	significant	increasing
		4	Feb-95	52	0.813	0.000	0.581	0.000	significant	increasing
		7	Jan-95	53	0.820	0.000	0.607	0.000	significant	increasing
		9	May-94	60	0.899	0.000	0.715	0.000	significant	increasing
		10	May-96	38	0.898	0.000	0.750	0.000	significant	increasing
		15	Mar-96	40	0.804	0.000	0.578	0.000	significant	increasing
		16	Mar-96	40	0.894	0.000	0.727	0.000	significant	increasing
		17	Apr-96	39	0.899	0.015	0.748	0.000	significant	increasing
		18	Oct-96	35	0.449	0.000	0.225	0.057	not significant	same
		19	Mar-96	41	0.821	0.000	0.613	0.000	significant	increasing
		20	Apr-96	40	0.630	0.000	0.397	0.000	significant	increasing
Strait of Juan de Fuca	Dungeness Bay	1	Jul-96	25	0.953	0.000	0.848	0.000	significant	increasing
		2	Jul-96	25	0.962	0.000	0.872	0.000	significant	increasing
		3	Jul-96	26	0.938	0.000	0.800	0.000	significant	increasing
		4	Jul-96	25	0.934	0.000	0.807	0.000	significant	increasing
		5	Jul-96	25	0.956	0.000	0.845	0.000	significant	increasing
		6	Jun-96	26	0.818	0.000	0.686	0.000	significant	increasing
		7	Aug-96	24	0.878	0.000	0.725	0.000	significant	increasing
		8	Jul-96	25	0.752	0.000	0.596	0.000	significant	increasing
		9	Jul-96	25	-0.007	0.972	0.035	0.805	not significant	same
		10	Jul-96	25	0.906	0.000	0.782	0.000	significant	increasing
		11	Aug-96	24	0.800	0.000	0.623	0.000	significant	increasing
		12	Jul-96	25	0.619	0.001	0.496	0.000	significant	increasing
		13	Aug-96	24	-0.432	0.035	-0.274	0.060	not significant	same
Admiralty Inlet	Port Gamble	14	Mar-97	18	0.733	0.000	0.653	0.000	significant	increasing
Admiralty Inlet	Port Gamble	15	Mar-97	19	0.836	0.000	0.665	0.000	significant	increasing

MARINE BODY	GROWING AREA	stn n.	earliest date stats available	Spearman n	Spearman Rho	Spearman p-level	Kendall Tau	Kendall p-level	conclusion	trend
Hood Canal	Area #3	1	Aug-95	26	0.921	0.000	0.799	0.000	significant	increasing
	(including	2	Aug-95	26	0.872	0.000	0.727	0.000	significant	increasing
	Quilcene)	3	Aug-95	26	-0.226	0.267	-0.167	0.231	not significant	same
		4	Sep-95	25	0.806	0.000	0.651	0.000	significant	increasing
		5	Sep-95	25	0.657	0.000	0.508	0.000	significant	increasing
		16	Aug-97	16	0.839	0.000	0.685	0.000	significant	increasing
		18	Nov-97	16	0.903	0.000	0.780	0.000	significant	increasing
		19	Oct-96	16	-0.838	0.000	-0.686	0.000	significant	decreasing
		20	Jan-97	13	0.412	0.162	0.295	0.160	not significant	same
	Area #3a	3	May-96	21	0.564	0.008	0.406	0.010	significant	increasing
	(including	5	May-96	21	0.688	0.000	0.513	0.001	significant	increasing
	Dosewalips)									
	Area #5	21	Apr-97	20	-0.257	0.273	-0.222	0.172	not significant	same
	(including	22	Mar-97	21	0.299	0.188	0.158	0.317	not significant	same
	Lilliwaup)	23	Mar-97	21	-0.304	0.180	-0.198	0.209	not significant	same
	Area #6	22	Mar-97	19	0.060	0.807	0.066	0.692	not significant	same
	(including	24	Mar-97	19	0.354	0.137	0.406	0.015	not significant	same
	Annas Bay)	25	Mar-97	19	0.599	0.007	0.599	0.003	significant	increasing
		26	Mar-97	19	0.969	0.000	0.882	0.000	significant	increasing
		27	Jun-97	17	0.223	0.389	0.237	0.185	not significant	same
		28	Mar-97	19	-0.005	0.982	0.070	0.676	not significant	same
		29	Mar-97	19	0.255	0.292	0.264	0.114	not significant	same
		30	Mar-97	19	0.441	0.059	0.484	0.004	not significant	same
		31	Mar-97	19	-0.162	0.507	-0.185	0.267	not significant	same
	Area #7	2	Mar-97	19	0.653	0.002	0.495	0.003	significant	increasing
		3	Apr-97	18	0.448	0.009	0.603	0.008	significant	increasing
		4	Mar-97	19	0.334	0.163	0.238	0.155	not significant	same
		5	Mar-97	19	0.398	0.090	0.373	0.025	not significant	same
		6	Mar-97	19	0.387	0.102	0.236	0.158	not significant	same
		7	Mar-97	19	0.764	0.001	0.630	0.000	significant	increasing
		8	Mar-97	19	0.834	0.000	0.709	0.000	significant	increasing
		10	Apr-97	18	0.354	0.150	0.259	0.133	not significant	same
		13	Mar-97	19	0.287	0.233	0.261	0.118	not significant	same
		14	Mar-97	19	0.951	0.000	0.869	0.000	significant	increasing

MARINE BODY	GROWING AREA	stn n.	earliest date stats available	n	Spearman Rho	Spearman p-level	Kendall Tau	Kendall p-level	conclusion	trend
	Area #8	1	Jul-97	17	-0.388	0.124	-0.314	0.079	not significant	same
		2	Jun-97	17	0.972	0.000	0.912	0.000	significant	increasing
		3	Apr-97	18	0.412	0.089	0.304	0.078	not significant	same
		4	Apr-97	18	-0.229	0.360	-0.266	0.124	not significant	same
		7	Apr-97	18	0.217	0.387	0.176	0.307	not significant	same
		9	Apr-97	18	0.393	0.107	0.346	0.045	not significant	same
		11	Apr-97	18	-0.908	0.000	-0.801	0.000	significant	decreasing
		16	Jun-97	17	0.853	0.000	0.762	0.000	significant	increasing
Hood Canal	Area #9	18	Mar-96	22	-0.754	0.000	-0.539	0.000	significant	decreasing
		19	Nov-96	26	-0.555	0.006	-0.414	0.006	significant	decreasing
		20	Mar-96	23	-0.013	0.949	0.188	0.851	not significant	same
Main Basin	Liberty Bay	21	Sep-96	21	0.246	0.281	0.366	0.020	not significant	same
		22	Feb-96	25	0.130	0.535	0.157	0.270	not significant	same
		23	Sep-96	21	0.092	0.692	0.240	0.128	not significant	same
		24	Sep-96	21	-0.667	0.000	-0.515	0.001	significant	decreasing
South Puget Sound	Filucy Bay	1	Jul-95	57	-0.240	0.072	-0.160	0.078	not significant	same
		2	Jul-95	58	0.591	0.000	0.473	0.000	significant	increasing
		7	Sep-95	56	-0.279	0.037	-0.165	0.073	not significant	same
		8	Sep-95	57	-0.339	0.010	-0.234	0.010	significant	decreasing
	Henderson Bay	1	Jan-97	24	0.969	0.000	0.898	0.000	significant	increasing
		2	Jan-97	24	0.902	0.000	0.752	0.000	significant	increasing
		3	Jan-97	24	0.858	0.000	0.696	0.000	significant	increasing
	Burley Lagoon	2	Jul-93	74	0.918	0.000	0.755	0.000	significant	increasing
		4	Jun-93	74	0.005	0.970	0.074	0.349	not significant	same
		5	Jul-93	73	0.435	0.000	0.287	0.000	significant	increasing
		6	Aug-93	71	0.019	0.872	0.032	0.000	not significant	same
		7	Aug-95	52	0.330	0.017	0.194	0.042	significant	increasing
		8	Jul-95	53	0.714	0.000	0.520	0.000	significant	increasing
		9	Aug-95	52	-0.423	0.000	-0.297	0.002	significant	decreasing
		10	Jul-93	73	0.342	0.003	0.280	0.000	significant	increasing
		11	Mar-95	56	0.219	0.106	0.066	0.473	not significant	same
		16	Aug-95	52	0.618	0.000	0.419	0.000	significant	increasing
		17	Sep-95	51	0.674	0.000	0.484	0.000	significant	increasing
		18	Jun-94	63	0.828	0.000	0.641	0.000	significant	increasing

MARINE BODY	GROWING AREA	stn n.	earliest date stats available	Spearman n	Spearman Rho	Spearman p-level	Kendall Tau	Kendall p-level	conclusion	trend
South	Nisqually	16	Mar-95	39	0.891	0.000	0.755	0.000	significant	increasing
Puget	Reach	17	Apr-94	70	0.923	0.000	0.766	0.000	significant	increasing
Sound		18	Feb-95	60	0.769	0.000	0.562	0.000	significant	increasing
		19	Jan-95	61	0.794	0.000	0.572	0.000	significant	increasing
		20	Jan-95	61	-0.778	0.000	-0.576	0.000	significant	decreasing
		21	Feb-95	59	-0.392	0.002	-0.254	0.004	significant	decreasing
		22	Feb-95	60	0.304	0.018	0.196	0.027	significant	increasing
		23	Jan-95	61	0.204	0.114	0.157	0.074	not significant	same
		24	Dec-94	62	0.405	0.001	0.293	0.001	significant	increasing
		25	Dec-94	62	0.198	0.122	0.123	0.156	not significant	same
		26	Dec-95	28	0.876	0.000	0.688	0.000	significant	increasing
		27	Jan-97	16	0.573	0.002	0.662	0.005	not significant	same
		32	Mar-95	40	0.730	0.000	0.569	0.000	significant	increasing
		33	Mar-95	40	0.855	0.000	0.716	0.000	significant	increasing
		34	Mar-95	58	0.180	0.175	0.151	0.094	not significant	same
		35	Apr-95	58	-0.513	0.000	-0.282	0.002	significant	decreasing
		36	Jan-95	61	-0.561	0.000	-0.282	0.001	significant	decreasing
		37	Dec-94	60	0.660	0.001	-0.471	0.000	significant	decreasing
		38	Jan-95	60	-0.317	0.013	-0.233	0.008	significant	decreasing
		39	Mar-95	39	0.794	0.000	0.600	0.000	significant	increasing
		40	May-95	38	0.517	0.001	0.275	0.015	significant	increasing
		41	Mar-95	39	0.366	0.022	0.198	0.076	not significant	same
		42	Jun-95	37	-0.087	0.609	-0.057	0.621	not significant	same
		51	Nov-95	35	0.064	0.716	0.073	0.583	not significant	same
	Henderson	3	Oct-90	98	0.620	0.000	0.448	0.000	significant	increasing
	Inlet	5	Oct-91	89	0.746	0.000	0.528	0.000	significant	increasing
		6	Aug-90	107	0.892	0.000	0.724	0.000	significant	increasing
		7	Jan-91	91	0.685	0.000	0.414	0.000	significant	increasing
		8	Aug-90	96	0.859	0.000	0.708	0.000	significant	increasing
		10	Aug-90	98	0.792	0.000	0.623	0.000	significant	increasing
		11	Nov-91	83	0.638	0.000	0.449	0.000	significant	increasing
		12	Aug-90	95	0.896	0.000	0.750	0.000	significant	increasing
		13	Dec-90	100	0.519	0.000	0.409	0.000	significant	increasing
		16	Dec-90	91	0.369	0.000	0.247	0.001	significant	increasing
		18	Sep-91	81	0.706	0.000	0.439	0.000	significant	increasing
		19	Jul-90	94	0.802	0.000	0.576	0.000	significant	increasing
		20	Jul-90	96	0.889	0.000	0.780	0.000	significant	increasing
		22	Sep-90	95	0.493	0.000	0.278	0.000	significant	increasing
		23	.Sep-90	96	-0.290	0.004	-0.114	0.098	not significant	same
		24	Jul-90	98	-0.147	0.149	-0.123	0.070	not significant	same
		25	Jul-90	98	0.497	0.000	0.357	0.000	significant	increasing
		26	Jul-90	98	0.715	0.000	0.524	0.000	significant	increasing
		27	Jul-90	98	0.754	0.000	0.572	0.000	significant	increasing
		28	.Jul-90	98	0.477	0.000	0.244	0.000	significant	increasing

MARINE BODY	GROWING AREA	stn n.	earliest date stats available	Spearman n	Spearman Rho	Spearman p-level	Kendall Tau	Kendall p-level	conclusion	trend
South Puget Sound	Eld Inlet	6	Dec-90	81	-0.237	0.033	-0.144	0.119	not significant	same
		7	Nov-90	89	-0.273	0.009	-0.173	0.019	significant	decreasing
		9	Oct-90	91	-0.190	0.070	-0.119	0.001	not significant	same
		10	Aug-90	98	-0.463	0.000	-0.335	0.000	significant	decreasing
		11	Oct-90	93	-0.026	0.804	-0.075	0.890	not significant	same
		12	Aug-90	100	-0.769	0.000	-0.590	0.000	significant	decreasing
		13	Aug-90	101	-0.832	0.000	-0.693	0.000	significant	decreasing
		14	Aug-90	102	-0.500	0.000	-0.333	0.000	significant	decreasing
		15	Sep-90	89	-0.816	0.000	-0.654	0.000	significant	decreasing
		16	Oct-90	88	-0.905	0.000	-0.778	0.000	significant	decreasing
		17	Aug-90	89	-0.756	0.000	-0.547	0.000	significant	decreasing
		18	Aug-90	88	-0.697	0.000	-0.288	0.000	significant	decreasing
		19	Sep-90	86	-0.634	0.000	-0.480	0.000	significant	decreasing
		20	Aug-90	89	-0.570	0.000	-0.390	0.000	significant	decreasing
		23	Aug-90	87	-0.862	0.000	-0.694	0.000	significant	decreasing
		25	Aug-90	87	-0.739	0.000	-0.500	0.000	significant	decreasing
.	North Bay	5	Apr-95	58	0.745	0.000	0.514	0.000	significant	increasing
		6	May-93	78	-0.445	0.000	-0.337	0.000	significant	decreasing
		7	May-93	79	-0.210	0.064	-0.159	0.038	not significant	same
		8	May-93	79	-0.608	0.000	-0.483	0.000	significant	decreasing
		9	Jun-93	78	0.612	0.000	0.401	0.000	significant	increasing
		10	Jul-93	78	0.361	0.001	0.250	0.001	significant	increasing
		17	Apr-95	57	-0.758	0.000	-0.574	0.000	significant	decreasing
		21	Feb-94	69	-0.470	0.412	-0.354	0.000	not significant	same
		22	Mar-94	69	-0.937	0.000	-0.804	0.000	significant	decreasing
		24	Jul-93	69	-0.838	0.000	-0.663	0.000	significant	decreasing
		25	Mar-94	69	-0.795	0.000	-0.604	0.000	significant	decreasing
		26	Mar-94	69	-0.149	0.221	-0.111	0.178	significant	increasing
		34	Mar-94	69	-0.803	0.000	-0.642	0.000	significant	decreasing
	Oakland Bay	3	Jul-90	110	-0.827	0.000	-0.626	0.000	significant	decreasing
		4	Jul-90	111	-0.848	0.000	-0.682	0.000	significant	decreasing
		5	Jul-90	110	-0.419	0.000	-0.291	0.001	significant	decreasing
		6	Jul-90	112	-0.432	0.000	-0.272	0.000	significant	decreasing
		7	Jul-90	112	-0.146	0.124	-0.104	0.105	not significant	same
		8	Jul-90	112	-0.254	0.007	-0.147	0.022	significant	decreasing
		9	Jul-90	111	-0.251	0.008	-0.203	0.002	significant	decreasing
		10	Jul-90	111	-0.458	0.000	-0.316	0.000	significant	decreasing
		11	Jun-90	113	-0.376	0.000	-0.218	0.001	significant	decreasing
		12	Jul-90	115	-0.673	0.000	-0.486	0.000	significant	decreasing
		16	Dec-93	118	0.387	0.001	0.220	0.006	significant	increasing
		17	Dec-93	73	-0.383	0.001	-0.263	0.001	significant	decreasing
		18	Jan-94	60	0.209	0.078	0.115	0.154	not significant	same

MARINE BODY	GROWING AREA	stn n.	earliest date stats available	n	Spearman Rho	p-level	Kendall Tau	p-level	conclusion	trend
South	Totten/	4	Nov-90	68	0.744	0.000	0.583	0.000	significant	increasing
Puget	Skookum	5	Nov-90	67	-0.736	0.000	-0.545	0.000	significant	decreasing
Sound	inlets	6	Nov-90	68	0.602	0.000	0.526	0.000	significant	increasing
		8	Nov-90	67	-0.750	0.000	-0.552	0.000	significant	decreasing
		9	Nov-90	66	0.715	0.000	0.578	0.000	significant	increasing
		10	Mar-91	57	-0.209	0.021	-0.264	0.047	significant	decreasing
		11	Sep-91	53	-0.831	0.000	-0.672	0.000	significant	decreasing
		17	Oct-90	69	-0.362	0.000	-0.281	0.000	significant	decreasing
		18	Oct-90	71	-0.713	0.000	-0.548	0.000	significant	decreasing
		19	Nov-90	68	-0.588	0.000	-0.383	0.000	significant	decreasing
		21	Dec-90	61	-0.877	0.000	-0.713	0.000	significant	decreasing

SUMMARY OF TRENDS	**TOTALS**	**%**
number of growing areas where trends were determined	**26**	
number of stations where trends were determined.	**226**	**100**
number of stations with "increasing" trend.	**104**	**46**
number of stations with "decreasing" trend.	**61**	**27**
number of stations with "no trend" (same).	**61**	**27**

Appendix C. Summary of fecal pollution status in shellfish growing areas of Puget Sound and the Strait of Juan de Fuca (January 1999-March 2000).

MARINE REGION	GROWING AREA	Total	number of stations			percentages			weighted percentages			IMPACT
		Stations	GOOD	FAIR	BAD	GOOD	FAIR	BAD	GOOD	FAIR	BAD	INDEX
Strait of Georgia	Drayton Harbor	6	0	1	5	0.0	16.7	83.3	0.0	33.3	250.0	**2.8**
Bellingham Bay	Portage Bay	8	4	1	3	50.0	12.5	37.5	50.0	25.0	112.5	**1.9**
	Samish Bay	24	16	3	5	66.7	12.5	20.8	66.7	25.0	62.5	**1.5**
Whidbey Basin	Similk Bay	11	11	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	south Similk Bay	16	16	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	south Skagit Bay	13	0	2	11	0.0	15.4	84.6	0.0	30.8	253.8	**2.8**
	Saratoga Passage	10	8	0	2	80.0	0.0	20.0	80.0	0.0	60.0	**1.4**
Admiralty Inlet	Possession Sound	36	36	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
Strait of Juan de Fuca	Dungeness Bay	13	5	5	3	38.5	38.5	23.1	38.5	76.9	69.2	**1.8**
	East Strait (incl. Pysht)	31	29	2	0	93.5	6.5	0.0	93.5	12.9	0.0	**1.1**
Admiralty Inlet	Oak Bay	8	8	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Port Gamble	20	19	0	1	95.0	0.0	5.0	95.0	0.0	15.0	**1.1**
Hood Canal	Area 1	26	26	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Area 2	26	26	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Area 3 (incl. Quilcene Bay)	23	21	2	0	91.3	8.7	0.0	91.3	17.4	0.0	**1.1**
	Area 3a (incl. Dosewallips)	21	20	0	1	95.2	0.0	4.8	95.2	0.0	14.3	**1.1**
	Area 4	23	23	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Area 5 (incl. Lilliwaup)	31	29	2	0	93.5	6.5	0.0	93.5	12.9	0.0	**1.1**
	Area 6 (incl. Annas Bay)	36	34	1	1	94.4	2.8	2.8	94.4	5.6	8.3	**1.1**
	Area 7	16	16	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Area 8	16	15	1	0	93.8	6.3	0.0	93.8	12.5	0.0	**1.1**
	Area 9	19	13	2	4	68.4	10.5	21.1	68.4	21.1	63.2	**1.5**
Main Basin	Eglon	7	7	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Kingston	8	8	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Port Madison	14	14	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Liberty Bay (Lemolo)	4	3	1	0	75.0	25.0	0.0	75.0	50.0	0.0	**1.3**
	Agate Passage	5	5	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Port Orchard	26	25	1	0	96.2	3.8	0.0	96.2	7.7	0.0	**1.0**
	Dyes Inlet (Chico Bay)	7	0	3	4	0.0	42.9	57.1	0.0	85.7	171.4	**2.6**
	Port Blakely	9	9	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Blake Island	5	5	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Colvos Passage	7	7	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	East Passage	21	21	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Quartermaster Harbor	13	12	1	0	92.3	7.7	0.0	92.3	15.4	0.0	**1.1**
South Puget Sound	Burley Lagoon	12	3	8	1	25.0	66.7	8.3	25.0	133.3	25.0	**1.8**
	Henderson Bay	14	9	1	4	64.3	7.1	28.6	64.3	14.3	85.7	**1.6**
	Filucy Bay	4	0	3	1	0.0	75.0	25.0	0.0	150.0	75.0	**2.3**
	Nisqually Reach	28	17	5	6	60.7	17.9	21.4	60.7	35.7	64.3	**1.6**
	Henderson Inlet	20	10	6	4	50.0	30.0	20.0	50.0	60.0	60.0	**1.7**
	Eld Inlet	22	20	2	0	90.9	9.1	0.0	90.9	18.2	0.0	**1.1**
	Totten-Skookum inlets	26	26	0	0	100.0	0.0	0.0	100.0	0.0	0.0	**1.0**
	Oakland Bay	13	11	2	0	84.6	15.4	0.0	84.6	30.8	0.0	**1.2**
	North Bay	13	10	3	0	76.9	23.1	0.0	76.9	46.2	0.0	**1.2**
	TOTALS	**711**	**597**	**58**	**56**	**84.0**	**8.2**	**7.9**				

Sum "No-impact" areas (impact index = 1.0):	**17**
Sum Impacted areas (impact index > 1.0):	**26**
Total areas:	**43**